

BULLETIN

of the

American Association of Petroleum Geologists

CONTENTS

DISTRIBUTION OF OCEANS AND CONTINENTS	
<i>BY W. G. WOOLNOUGH</i>	1981
RECENT TRENDS IN GEOLOGICAL-GEOPHYSICAL EXPLORATION	
<i>BY R. CLARE COFFIN</i>	2013
GEOLOGICAL NOTES	
Elmore Embayment, Garvin County, Oklahoma <i>By Robert R. Wheeler</i>	2034
DISCUSSION	
Statistics of Exploratory Drilling <i>By W. J. Dixon and R. M. Swesnik</i>	2035
Tectonic Framework of Northwestern South America <i>By F. E. von Estorff</i>	2040
RESEARCH	
Final Reports on a Reconnaissance Survey of Research Needs in Petroleum Geology by the American Association of Petroleum Geologists Re- search Committee, 1945-1946. Foreword <i>By Shepard W. Lowman</i>	2042
Report of Sub-Committee on Tectonics <i>By Philip B. King</i>	2042
REVIEWS AND NEW PUBLICATIONS	
Petroleum Production Engineering—Oil Field Development, by Lester Charles Uren <i>By Harry H. Power</i>	2064
Geología de Bolivia, by F. Ahlfeld <i>By Norman D. Newell</i>	2065
Recent Publications	2067
THE ASSOCIATION ROUND TABLE	
Association Committees	2071
Membership Applications Approved for Publication	2074
Regional Meeting, Biloxi, Mississippi, October 24-25, 1946 <i>By Gordon I. Atwater</i>	2075
Mid-Continent Regional Meeting, Wichita, Kansas, January 16-17, 1947	2078
Functions and Organization of Geologic Names and Correlations Committee <i>By Henry J. Morgan, Jr.</i>	2079
Nominees for Officers	2082
Pacific Section Annual Meeting, Los Angeles, California, November 7-8, 1946	2087
New Rock-Color Chart for Field Use	2091
AT HOME AND ABROAD	
Current News and Personal Items of the Profession	2093
INDEX OF VOLUME 30 (1946)	2097



No. 3 of a Series

Guiding WORLD WIDE EXPLORATION

Argentina, British Guiana, Canada, Colombia, Hungary, Iran, Java, Little America, Mexico, Poland, Romania, Trinidad, United States of America and Venezuela.



The benefits of our exploration experiences in these areas are reflected in advanced techniques, experienced personnel, adequate equipment and more Accurate Records.

Seismograph Service Corporation

TULSA, OKLAHOMA, U. S. A.

BULLETIN*of the***AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS**

OFFICE OF PUBLICATION, 708 WRIGHT BUILDING, TULSA, OKLAHOMA

GAYLE SCOTT, Editor

TEXAS CHRISTIAN UNIVERSITY, FORT WORTH 9, TEXAS

ASSOCIATE EDITORS**GENERAL****APPALACHIANS****NORTH CENTRAL STATES****KANSAS****OKLAHOMA***Western**Eastern***TEXAS***North and Central**Northeastern**San Antonio**Permian Basin***GULF COAST****EASTERN GULF****ARKANSAS AND NORTH LOUISIANA****ROCKY MOUNTAINS****CALIFORNIA****CANADA****SOUTH AMERICA**

K. C. HEALD, Gulf Oil Corporation, Box 1166, Pittsburgh 30, Pa.
 HUGH D. MISER, U. S. Geological Survey, Washington 25, D. C.
 THERON WASSON, Pure Oil Company, 35 E. Wacker Drive, Chicago 1, Ill.
 RICHARD E. SHERRILL, University of Pittsburgh, Pittsburgh 13, Pa.
 R. B. NEWCOMBE, Superior Oil Company, Grand Rapids, Mich.
 EDWARD A. KOESTER, Darby and Bothwell, Inc., Wichita 2, Kan.

ROBERT H. DOTT, Oklahoma Geological Survey, Norman, Okla.
 SHERWOOD BUCKSTAFF, Shell Oil Company, Inc., Box 1101, Tulsa 2, Okla.

J. B. LOVEJOY, Gulf Oil Corporation, Fort Worth 1, Tex.
 C. I. ALEXANDER, Magnolia Petroleum Company, Tyler, Tex.
 JOHN R. SANDIDGE, Magnolia Petroleum Company, San Antonio 5, Tex.
 E. RUSSELL LLOYD, Box 1026, Midland, Tex.
 SIDNEY A. JUDSON, Texas Gulf Producing Company, Houston 1, Tex.
 MARCUS A. HANNA, Gulf Oil Corporation, Houston 1, Tex.
 HENRY N. TOLER, Southern Natural Gas Company, Jackson, Miss.
 ROY T. HAZZARD, Gulf Refining Company of Louisiana, Shreveport 03, La.
 A. E. BRAINERD, Continental Oil Company, Denver 2, Colo.
 W. D. KLEINFELL, Box 1131, Bakersfield, Calif.
 E. R. ATWILL, Union Oil Company of California, 617 W. 7th, Los Angeles 14
 THEODORE A. LINK, Imperial Oil Limited, Toronto, Ontario
 HOLLIS D. HEDBERG, Gulf Oil Corporation, 17 Battery Place, New York, N.Y.

THE BULLETIN is published by the Association on the 15th of each month.

EDITORIAL AND PUBLICATION OFFICE AND ASSOCIATION HEADQUARTERS, 708 Wright Building, 115 and 117 West Third Street, Tulsa, Oklahoma. Post Office, Box 970, Tulsa 1.

BRITISH AGENT: Thomas Murby & Co., 40 Museum Street, London, W. C. 1.

SUBSCRIPTION PRICE to non-members is \$15 per year (separate numbers, \$1.50), prepaid to addresses in the United States; outside the United States, \$15.40.

CLAIMS FOR NON-RECEIPT must be sent within 3 months of date of publication, to be filled gratis.

BACK NUMBERS, if available, may be ordered from Headquarters. Price list on request.

			<i>Mem.</i>	<i>Non-Mem.</i>
Cloth-bound Bulletin, Vols. 12 (1928)-15 (1931) incl., each.....			\$5.00	\$ 6.00

SPECIAL PUBLICATIONS	<i>Mem.</i>	<i>Non-Mem.</i>	SPECIAL PUBLICATIONS	<i>Mem.</i>	<i>Non-Mem.</i>
1936. Geology of Tampico Region	3.50	4.50	1941 Future Oil Provinces, U. S.		
1936. Map of Southern California	.50	.50	& Canada	1.00	1.50
1938. Miocene Stratigraphy of California.....	4.50	5.00	1941. Stratigraphic Oil Fields ...	4.50	5.50
			1944. Tectonic Map of U. S. ...	2.00	2.00

Communications about the Bulletin, manuscripts, editorial matters, subscriptions, special rates to public and university libraries, publications, membership, change of address, advertising rates, and other Association business should be addressed to

**THE AMERICAN ASSOCIATION OF PETROLEUM
GEOLOGISTS, INC.**

J. P. D. HULL, BUSINESS MANAGER
 BOX 979, TULSA 1, OKLAHOMA

Entered as second-class matter at the Post Office at Tulsa, Oklahoma, and at the Post Office at Menasha, Wisconsin, under the Act of March 3, 1879. Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized March 9, 1913.

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS, INC.

Organized at Tulsa, Oklahoma, February 10, 1917, as the Southwestern Association of Petroleum Geologists. Present name adopted, February 16, 1918. Incorporated in Colorado, April 23, 1924. Domesticated in Oklahoma, February 9, 1925.

OFFICERS FOR THE YEAR ENDING MARCH, 1947

EARL B. NOBLE, *President*, Los Angeles, California
 EDWARD A. KOESTER, *Secretary-Treasurer*, Wichita, Kansas
 D. PERRY OLCOTT, *Vice-President*, Houston, Texas
 GAYLE SCOTT, *Editor*, Fort Worth, Texas
 The foregoing officers, and the *Past-President*, MONROE G. CHENEY, Coleman, Texas, constitute the Executive Committee.

DISTRICT REPRESENTATIVES (Terms expire after annual meetings of years shown in parentheses)

Amarillo: Elisha A. Paschal (48), Amarillo, Tex.
Appalachian: W. O. Ziebold (47), Charleston, W. Va.
Canada: Edwin H. Hunt (47), Calgary, Alberta
Capital: Carl H. Dane (48), Washington, D. C.
Corpus Christi: Ira H. Stein (47), Alice, Tex.
Dallas: W. Dow Hamm (48), Dallas, Tex.
East Oklahoma: J. L. Borden (47), Glenn D. Hawkins (47), Frank R. Clark (48), Tulsa; Robert L. Kidd (48), Bartlesville
Fort Worth: Lynn K. Lee (47), Fort Worth, Tex.
Great Lakes: Robert M. English (47), Mattoon, Ill.
 Stanley G. Elder (48), Evansville, Ind.
Houston: A. P. Allison (47), P. B. Leavenworth (47), Ira H. Brinkerhoff (48), Shirley L. Mason (48), Olin G. Bell (48), Houston, Tex.
Michigan: E. J. Baltrusaitis (47), Saginaw, Mich.
New Mexico: Georges Vorbe (47), Socorro, N. Mex.
New York: Gail F. Moulton (47), New York City

Pacific Coast: Rollin Eckis (47), Glenn C. Ferguson (47), Bakerville, Calif.; Frank W. Bell (48), Sacramento; Claude E. Leach (48), Ventura; D. E. Taylor (48), Long Beach
Rocky Mountains: Robert L. Sleaf (47), Casper, Wyo.; H. E. Christensen (48), Denver, Colo.
Shreveport: G. D. Thomas (47), Shreveport, La.
South America: L. W. Henry (47), Caracas, Venezuela
Southeast Gulf: Henry N. Toler (47), Jackson, Miss.
Southern Louisiana: Max Bornhauser (47), Lafayette
So. Permian Basin: George R. Gibson (47), Warren D. Anderson (48), Midland, Tex.
South Texas: Adolph Dovre (47), Wesley G. Gish (48), San Antonio
Tyler: J. S. Hudnall (47), Tyler, Tex.
West Oklahoma: Jerry B. Newby (47), Oklahoma City;
 C. W. Tomlinson (48), Ardmore
Wichita: John W. Inkster (47), Wichita, Kan.
Wichita Falls: J. J. Russell, Jr. (48), Wichita Falls, Tex.

DIVISION REPRESENTATIVES

Paleontology and Mineralogy: F. W. Rolshausen (47), Houston, Texas; Henryk B. Stenzel (47), Austin, Texas

PACIFIC SECTION (Chartered, March, 1925)

E. R. ATWILL, *President*, Union Oil Company of California, 617 W. 7th Street, Los Angeles, California
 VINCENT W. VANDIVER, *Vice-President*, Seaboard Oil Company, 417 S. Hill Street, Los Angeles 13
 ASHLY S. HOLSTON, *Secretary-Treasurer*, Tide Water Assoc. Oil Company, 801 Pacific Electric Bldg., Los Angeles
 Membership restricted to members of the Association in good standing, residing in Pacific Coast states. Dues: \$2.00 per year.

SOUTH TEXAS SECTION (Chartered, April, 1920)

THORNTON DAVIS, *President*, Peerless Oil and Gas Co., 2023 Alamo National Building, San Antonio, Texas
 PAUL B. HINYARD, *Secretary-Treasurer*, Shell Oil Co., 2000 Alamo National Building, San Antonio, Texas
 Membership limited to persons eligible to Association membership. Dues: \$2.50. Annual meeting in October.

EASTERN SECTION (Chartered, April, 1946)

BEN F. HAKE, *President*, Gulf Oil Corporation, 17 Battery Place, New York, N.Y.
 L. G. WEEKS, *Secretary*, Standard Oil Company (N. J.), Room 2150, 30 Rockefeller Plaza, New York, N. Y.
 Membership restricted to members of the Association in good standing, residing in New York district.

DIVISION OF PALEONTOLOGY AND MINERALOGY SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS

(Organized, March, 1927; affiliated, March, 1928; chartered, technical division, April, 1930)

F. W. ROLSHAUSEN, *President*, Humble Oil and Refining Company, Houston, Texas

HENRYK B. STENZEL, *Secretary-Treasurer*, Bureau of Economic Geology, Austin 12, Texas

SEND DUES, SUBSCRIPTIONS AND ORDERS FOR BACK NUMBERS TO BOX 970, TULSA 1, OKLAHOMA. The Society and the Paleontological Society jointly issue six times a year the *Journal of Paleontology*, J. Marvin Weller, University of Chicago, Chicago 37, Illinois, and C. Wythe Cooke, U. S. National Museum, Washington, D. C., editors; subscription, \$6.00. The *Journal of Sedimentary Petrology*, W. H. Twenhofel, editor, University of Wisconsin, Madison, Wisconsin, is issued three times a year; subscription, \$3.00. Single copies, *Journal of Paleontology*, \$2.00; *Journal of Sedimentary Petrology*, \$1.50. Society dues with *Jour. Pal.*, \$5.00; with *Jour. Sed. Petrology*, \$3.00; with both, \$8.00 per year.

AFFILIATED SOCIETIES (Dates of affiliation in parentheses)

Alberta Society of Petroleum Geologists, Calgary, Alberta, Canada (31)
 Appalachian Geological Society, Charleston, W. Virginia (21)
 Ardmore Geological Society, Ardmore, Oklahoma (36)
 Corpus Christi Geological Society, Corpus Christi, Texas (43)
 Dallas Geological Society, Dallas, Texas (35)
 East Texas Geological Society, Tyler, Texas (32)
 Fort Worth Geological Society, Fort Worth, Texas (31)
 Houston Geological Society, Houston, Texas (32)
 Illinois Geological Society (39)
 Indiana-Kentucky Geological Society (38)
 Kansas Geological Society, Wichita, Kansas (31)
 Michigan Geological Society (37)
 Mississippi Geological Society, Jackson, Miss. (41)
 New Orleans Geological Society, New Orleans, La. (43)
 North Texas Geological Society, Wichita Falls, Texas (38)
 Oklahoma City Geological Society, Oklahoma City, Okla. (31)
 Panhandle Geological Society, Amarillo, Texas (32)
 Shawnee Geological Society, Shawnee, Oklahoma (31)
 Shreveport Geological Society, Shreveport, Louisiana (32)
 Society of Exploration Geophysicists (32)
 South Louisiana Geological Society, Lake Charles, La. (37)
 Southeastern Geological Society, Tallahassee, Fla. (44)
 Tulsa Geological Society, Tulsa, Oklahoma (31)
 West Texas Geological Society, Midland, Texas (38)
 Wyoming Geological Association, Box 245, Casper (45)
 Yellowstone-Bighorn Research Association, Inc. (44)
 W. P. Hancock Secy., Imperial Oil Ltd., 339 7th Av. W.
 R. E. Alkire, Secy., 605 Union Building
 Ben S. Curtis, Secy., Independent, Box 156
 O. G. McLain, Secy., Consultant, 224 Nixon Building
 John M. Clayton, Secy., Seaboard Oil Co., 1400 Continental Bldg.
 B. F. Murphy, Secy., Amerada Petroleum Corporation, Box 2036
 S. K. Van Steenbergh, Secy., Sinclair Prairie Oil Co., 901 Fair Bldg.
 A. F. Childers, Secy., Gulf Oil Corporation, Box 2100
 John B. Patton, Secy., Magnolia Petroleum Company, Box 535, Mt. Vernon
 F. H. Laiter, Secy., Sun Oil Company, Evansville, Ind.
 F. E. Mettner, Secy., Transwestern Oil Co., 605 Union Natl. Bank Bldg.
 Charles K. Clark, Secy., Pure Oil Co., 402 Second National Bank Bldg., Saginaw
 H. L. Spyres, Secy., Skelly Oil Company
 Philip R. Allin, Secy., Gulf Refining Company, Box 37, Harvey, La.
 D. T. Richards, Secy., c/o Geo. W. Graham, 400 Wagoner Bldg.
 Frederick H. Kate, Secy., Shell Oil Company, Inc.
 Phillips Petroleum Company
 Marcelle Mousley, Secy., Atlantic Refining Company, Box 169
 J. Ed. Lytle, Secy., Union Producing Company
 Carter Oil Company, Shreveport, Louisiana
 Ohio Oil Company
 Magnolia Petroleum Co., Box 1198
 John R. Crain, Secy., Ashland Oil and Refining Company
 Charles A. Shaw, Secy., Forest Oil Corporation, Box 366
 William A. Thompson, Secy., The Texas Company
 W. T. Thom, Jr., Secy., Princeton, N. J.

***There are a good many reasons
why critical geophysicists prefer***

HALOID RECORDS

SEISMOGRAPH RECORDING PAPER

Haloid Record is plenty tough, resists heat, withstands humidity and always provides sharp lines and legible contrast.

Even under the most adverse conditions, in the field or in the laboratory, you can depend on Haloid Record to give you consistently high performance. Superior geophysical recordings are yours because Haloid Record successfully combines the advantages of photographic excellence and resistance to abuse.

THE HALOID CO., 461 Haloid St., Rochester 3, N.Y.

Christmas comes
But once a year
And so you see
That's why I'm here.

A Merry Christmas
I've for you
A Happy Prosperous
New Year, too!



MAYES-BEVAN
GRAVITY MEER
SURVEYS
COMPANY

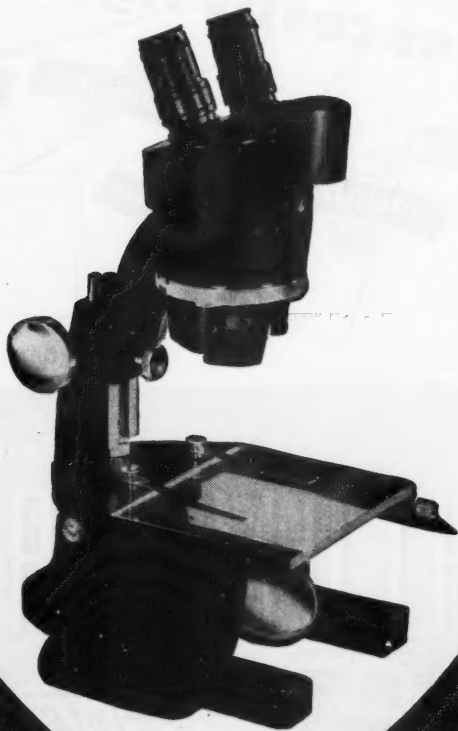
KENNEDY BLDG. TULSA, OKLAHOMA

A MICROSCOPE FOR EACH EYE

Spencer Stereoscopic Microscopes provide a complete microscope optical system for each eye, thereby creating vivid depth perception. They are noted for *large field . . . brilliant resolution . . . great depth of focus*. Magnifications range from

6x to 144x. For descriptive literature on Spencer Stereoscopic Microscopes write to Dept. M29.

American  Optical
COMPANY
Scientific Instrument Division
Buffalo 15, New York



Manufacturers of the **SPENCER** *Scientific Instruments*

1 *One trip to the well*

PROVIDES ALL THESE SERVICES...
saves costly rig time!



SCHLUMBERGER



Integrated
WELL SERVICE

SCHLUMBERGER WELL SURVEYING CORPORATION • HOUSTON • TEXAS

Bulletin Advertisers

Advanced Exploration Company	xxvii	Journal of Geology	xxii
Aero Service Corporation	xxii	Journal of Paleontology	xxii
American Optical Company	v	Journal of Sedimentary Petrology	xxii
American Paulin System	xxvi	Keystone Exploration Company	xxvii
Atlas Powder Company	lv	Koenig Iron Works	xliv
Baker Oil Tools, Inc.		Lane-Wells Company	xxv
Baroid Sales Division	xxix	Laughlin-Simmons and Company	lii
Barret, William M., Inc.	xxiii	Lufkin Rule Company	xlii
Dowell Incorporated		Mayes-Bevan Company	iv
Eastman Oil Well Surveys	xlx	North American Geophysical Company	xxxv
Economic Geology Publishing Company	xxii	Petty Geophysical Engineering Company	xxxviii
Exploration Geophysics	xlii	Reed Roller Bit Company	Cover iii
Failing (Geo. E.) Supply Co.	1	Robert H. Ray Co.	xxxii
Fairchild Aerial Surveys	xliii	Rogers-Ray, Inc.	xxxiii
First Natl. Bank and Trust Co. of Tulsa	xlx	Scientia	xlx
C. H. Frost Gravimetric Surveys	xlx	Schlumberger Well Surveying Corporation	vi
General Geophysical Company	xxviii	Seismic Explorations, Inc.	xxxiv
Geological Society of America	li	Seismograph Service Corporation	Cover ii
Geophysical Service, Inc.	viii	Society of Exploration Geophysicists	xlii
Geophysical Exploration Company		Southern Geophysical Company	xxxix
Geotechnical Corporation	xlx	Sperry-Sun Well Surveying Company	xxxvii
Gravity Meter Exploration Company	xli	Sullivan Division, Joy Mfg. Co.	xx-xxi
Gulf Publishing Company	xlviii	Thompson Tool Company, Inc.	
Haloid Company	iii	Tobin (Edgar) Aerial Surveys	liii
Heiland Research Corporation	xxxvi	Triangle Blue Print and Supply Company	
Hercules Powder Company, Inc.		United Geophysical Company	xxiv
Hughes Tool Company	Cover iv	Universal Exploration Company	xlx
Independent Exploration Company	xl	Western Geophysical Company	xxx

PROFESSIONAL CARDS

Alabama	ix	Louisiana	x	Ohio	xi
California	ix	Mississippi	x-xi	Oklahoma	xi-xii
Colorado	ix-x	Montana	xi	Pennsylvania	xii
Illinois	x	New Mexico	xi	Texas	xii, xiii, xiv, xv
Indiana	x	New York	x	West Virginia	xv
Kansas	x	North Carolina	xi	Wyoming	xv

GEOLOGICAL AND GEOPHYSICAL SOCIETIES

Appalachian	xviii	Illinois	xvi	Shawnee	xvii
Ardmore	xvii	Indiana-Kentucky	xvi	Shreveport	xvi
Corpus Christi	xvii	Kansas	xvi	Southeastern	xvi
Dallas	xvii	Michigan	xvii	South Texas	xviii
East Texas	xviii	Mississippi	xvii	South Louisiana	xvi
Exploration Geophysicists	xix	New Orleans	xvi	Tulsa	xvii
Fort Worth	xviii	North Texas	xviii	West Texas	xviii
Houston	xviii	Oklahoma City	xvii	Wyoming	xviii
		Rocky Mountain	xvi		

Articles for January Bulletin

Stratigraphy of Western Australia

By Curt Teichert

Stratigraphic Paleontology of Camaguey District, Cuba

By J. F. de Albear

Relation of Crude Oils and Stratigraphy in Parts of Oklahoma and Kansas

By Tulsa Geological Society Research Committee

Seismograph Surveys



BULLETIN
of the
AMERICAN ASSOCIATION OF
PETROLEUM GEOLOGISTS

DECEMBER, 1946

DISTRIBUTION OF OCEANS AND CONTINENTS—A SUGGESTION¹

W. G. WOOLNOUGH²
Melbourne, Victoria, Australia

ABSTRACT

The paper is an attempt to reconcile two apparently contradictory theories regarding the distribution of oceans and continents on the earth's surface, namely, the Tetrahedral theory and Wegener's hypothesis. Each of these theories accounts eminently satisfactorily for a large series of important objective facts; but, by itself, fails to explain another series of equally important facts inherent in the other.

The Tetrahedral theory has a sound mathematical and physical basis. The antipodal distribution of lands and oceans on the earth at present is in such close agreement with the positions demanded by theory that the "fit" can not be disregarded and looked upon as entirely fortuitous. Yet there are outstanding anomalies such as the overlap of Patagonia and China in an antipodal map, and the position of the northern continents with an average latitude of 45° N. Such discrepancies must be explained if possible.

Wegener's hypothesis accounts for so many undisputed facts in connection with geology, paleontology, and climate, otherwise absolutely incredible, that its main thesis of continental drift must be accepted, at least as far as the southern continents and India are concerned. The glacial features of Gondwana land, the distribution of the *Glossopteris-Gangamopteris* flora, and of the associated marine and land faunas of all the southern continents and of Peninsular India fit into the framework of a southern continent, with a center of ice distribution near Madagascar. No other suggestion can account for the objective facts involved. For South America, South Africa, India, Australia, and Antarctica to present the evidences of former close association which they unquestionably do, nothing but continental drift on a major scale can be visualized.

Reasons are given for suggesting that the outstanding anomalies may be eliminated, and the apparent paradoxes brought into complete harmony by assuming that, while the tetrahedroid tendency of a contracting and solidifying globe has played a very important part in earth history, its initial stages of development were interfered with and distorted by the early asymmetrical development of the Pacific Ocean basin, which is still a geographical element of abnormal character and dimensions. Whatever may be the ultimate cause of this gigantism of the Pacific Ocean, the fact is an objective one.

It is suggested that the theory put forward by G. H. Darwin, that the Pacific Ocean represents the scar left on the earth mass by tidal separation of the moon, be reexamined from a new angle. The bulk of the paper is devoted to an analysis of the results of such a phenomenon, which may, by analogy with physiological nomenclature, be termed a traumatic lesion of the earth body.

¹ Manuscript received, April 3, 1946.

² "Callabonna," Park Avenue, Gordon, New South Wales. Late geological adviser to the Commonwealth of Australia. The writer desires gratefully to acknowledge the valuable assistance given by Frank Canavan, geologist, Broken Hill Proprietary Company, Limited, Melbourne, who discussed the problem and had the manuscript and figures prepared for publication by members of his staff.

Reasons are given for supposing that such an injury, taking place some time after the earth had developed a permanent solid crust, could have caused "congenital deformity" of the embryonic tetrahedron, the development of which can be visualized as commencing some time after the initial formation of a solid crust. It is thought that the presence of the Pacific scar was responsible for the displacement of the Antarctic quoin of the tetrahedron toward South Africa, which is antipodal to the Pacific depression. The dihedral edges of the tetrahedron connected with this quoin were similarly twisted, leading to the development of the Gondwana continent.

Incidentally, it is suggested that there is no need to assume, as is done in Wegener's hypothesis, that the center of ice distribution in Permo-Carboniferous time was the South Pole of the earth of that period. This assumption involves a number of serious paradoxes, and is not acceptable to astronomers and geophysicists.

It is thought that the traumatic lesion of the earth was more severe in the South Pacific than was the case in the North Pacific, and that the development of the northern continental masses in such high northern latitudes may be a consequence of this.

As cooling of the earth proceeded, and ever deeper zones of the earth's interior ceased to alter their surface areas, the tetrahedroid tendency asserted itself in them. Such deeper zones were not controlled by the Pacific scar. As the tetrahedroid stresses accumulated they attained critical dimensions and carried the roots of the continental masses imbedded in the contracting zones nearer to the positions of ideal tetrahedroid symmetry. This gives a motive power for Wegenerian drift which is lacking in the original presentation.

Since accumulation and relief of stress are both gradual, a reason is provided for the periodicity of eras of orogeny. At the same time adequate amounts of kinetic energy, always a problem in dealing with the phenomena of diastrophism, are made available. Such effects are in no way exclusive of the results of radioactivity, sedimentation of geosynclines, internal flow of earth temperatures, and so on, but are complementary to them.

Reasons are adduced for believing that it was not until the initiation of Hercynian diastrophism that "dehiscence" of the Gondwana land knot occurred, initiating the rapid and extensive continental drift which has been shared by all the southern continents and Peninsular India.

The immediate effects of this drift are examined. It is shown that India has not yet reached its normal tetrahedral position between the Sino-Siberian shield and the Western Australian one, having been delayed by having had to plow through the enormously thick sediments of the great geosyncline of southwestern Asia, which geosyncline must be interpreted as the functional northerly extension of the Indian Ocean. In its later movements India has caused the crumpling of the greatest mass of fold mountains in the world.

South America, also, has not yet reached its allotted place in the tetrahedral symmetry, south of the Canadian shield. Had it done so, it would have become exactly antipodal to the Turkestan-Caspian region, which, as just mentioned, is functionally the northern end of the Indian Ocean.

A further suggestion is that when the Pacific was produced the ragged edges of the scar were left, and have persisted ever since as a circum-Pacific ring of earth structure. The possible effects of such a highly hypothetical structure are analyzed, and the suggestion is advanced that it may assist in explaining certain tectonic features such as the distribution and limitations of Laramide folding, and the remarkable loops and tectonic complexities encountered in the Caribbean, Moluccan, and Falkland Island regions.

INTRODUCTION

Of attempts to solve the problems connected with the distribution of land and sea on the earth's surface, and of their relations to tectonic zones, there is, as in "the making of books," no end. Many of the most accomplished thinkers have approached the subject and have propounded theories more or less plausible; but still there remain anomalies, contradictions, and paradoxes. The writer has no hope of solving finally this riddle of the Sphinx, but it is possible that the suggestions here advanced may attract others to approach this intriguing and profoundly important subject from a different angle.

Two outstanding hypotheses concerning the distribution of continental masses on the earth's surface have, individually, so many points in their favor that it seems incredible that either of them should be fundamentally fallacious. Yet, at first glance, they appear as paradoxical as the co-existence of light and darkness.

Each hypothesis seems to account perfectly satisfactorily for a wide range of objective phenomena of whose existence and magnitude there can be no doubt. The hypotheses in question are the Tetrahedral Theory of Earth Form, elaborated from the data of earlier workers by J. W. Gregory 50 years ago, and the intriguing Theory of Continental Drift advanced by Wegener. The one hypothesis appears to indicate the essential permanence of oceanic and continental sectors; the essence of the other is the almost incredible mobility of continental features.

Is there no possible suggestion which can bridge the gulf separating them?

OBJECTIVE FACTS

The following objective facts³ in relation to earth form and structure include some of the most important which must be accounted for by any acceptable theory. The list is by no means exhaustive.

1. Uniqueness of size and form of the Pacific Ocean basin
2. Extreme complexity of the tectonic features of the East Indies and Caribbean areas; and of the Cape Horn region (?)
3. Circum-Pacific development of Laramide folding
4. The great continental mass of Europe, Asia, and Africa
5. Comparatively symmetrical arrangement of earth units in relation to the terrestrial axis of rotation
6. Situation and permanence of Archean shields
7. Antipodal arrangement of continents and oceans
8. Tetrahedral theory
9. Permanence of ocean basins: rarity or absence of true abyssal deposits on continental areas
10. Wegener's hypothesis
11. Structural, paleontological and climatic unit of Gondwana land
12. Periodicity of principal eras of orogeny
13. Migration of loci of tectonic action
14. Relation of granitic injections to mountain folding

It is proposed to divide this paper into two parts: the first dealing mainly with the outstanding features of the objective facts already referred to, with incidental references only to their theoretical implications; the second part developing the more speculative ideas which constitute the thesis of this paper. Suggestions are advanced for testing the balance between the objective facts and the minor speculations arising therefrom. Several frankly speculative suggestions are put forward. These do not appear to be capable of either proof or disproof; and their acceptance or rejection is not vital to the main thesis.

PART I

I. UNIQUENESS OF SIZE AND FORM OF PACIFIC OCEAN BASIN

The most perfunctory inspection of a map of the earth, on any kind of projection, reveals the fact that the Pacific Ocean basin is much the most extensive individual unit of terrestrial structure. Its colossal area, the comparatively simple

³ Items 8 and 10 in the list are not objective facts, strictly speaking. Since, however, only those aspects of these questions which will be universally accepted by the majority of geologists are dealt with in this section, they have purposely been included here. The debatable aspects are relegated to the second part of the paper in which controversial subjects are dealt with.

contour of its boundaries and the absence from it of any considerable land masses all require investigation and explanation.

Its dominating importance as a terrestrial unit becomes ever more and more apparent as the nature and structure of its islands are examined, the individual characteristics of its shore lines are studied, and its relation to continental drift is made apparent.

When all these facts are considered together, and in direct contrast with the features of other ocean basins, it is difficult to escape the conclusion that so enormous and unique an element of earth structure demands some stupendous and unique mode of origin.

So great an astronomer and mathematician as G. H. Darwin did not hesitate seriously to advance the suggestion of the birth of the moon as the result of budding-off of an excrescence from the earth's mass as a result of rotational effects. He went so far as to compare the volume of the moon with the volume of the Pacific Ocean depression, and to venture the suggestion that that great and anomalous earth unit represented the moon scar. Certainly this suggestion has been violently opposed by many leading men of science, and few, if any, have the temerity to accept it wholly. Still, it is a suggestion put forward seriously by a great thinker, and, as such, is entitled to respectful consideration. No other satellite in the Solar system bears to its planet a mass relationship at all comparable with that which exists in the case of the Earth-Moon couple. This, in itself, suggests a mode of origin out of the usual.

Another suggestion is that the Pacific depression was scooped out by the impact of a colliding heavenly body, or as the result of the excessive tidal effects of a very near approach by one.

Whatever be the origin of the depression, the objective fact is that the Pacific Ocean is an anomalous earth unit. If it is of very ancient origin it must have imposed an initial asymmetry on all subsequent development—an influence which, the writer believes, it is still exerting.

2. EXTREME COMPLEXITY OF TECTONIC FEATURES OF EAST INDIES AND CARIBBEAN AREAS: AND OF CAPE HORN REGION (?)

In dealing with Cenozoic tectonics it is usually held that the zone of Alpine folding completely surrounds the Pacific Ocean, involving formations of late Mesozoic and early Tertiary age in its compression.

The main zone of Alpine folding, however, begins in western Europe, includes the whole of the mountain systems of southern Europe and those of northern Africa, those of Asia Minor, the Himalayas and southern Siberia; then, with sharp flexure of strike, the foldings of the Malay Peninsula and of the partially submerged mountain axis of the East Indies, abutting almost perpendicularly on the circum-Pacific ring in the extraordinarily complex tectonic knot of the Moluccas. In regard to this particular sector there has been much controversy, and no finality appears to have been attained.

On the other side of the Pacific, "Alpine" folding runs the whole length of both Americas, and there is a second region of high tectonic complexity in the Caribbean area.

A third region of considerable complexity, marked by extraordinary looping of the fold axes, exists at the extreme southern end of South America, and runs through the Falkland and South Shetland islands into Antarctica. From its situation this region has attracted less general attention than have the other two.

3. CIRCUM-PACIFIC DEVELOPMENT OF LARAMIDE FOLDING

Around the Atlantic and Indian oceans there was no general development of the late Mesozoic diastrophism which is so strongly marked and well differentiated in the Rocky Mountains of North America, where it is referred to by American geologists as the Laramide period of orogeny.

Obruchev⁴ and other Russian geologists emphasize the existence of a similar epoch of diastrophism in eastern Asia, so that its development appears to be bilateral with regard to the *northern* Pacific. On the shores of the *southern* Pacific such Laramide folding is by no means so outstanding a feature, if, indeed it can be recognized as a separate entity.

The foregoing facts appear to be objective enough to be widely accepted. The more subjective and speculative analysis of them will be attempted later.

4. GREAT CONTINENTAL MASS OF EUROPE, ASIA, AND AFRICA

A second unit of earth structure, scarcely less disproportionate than is the Pacific basin, is the composite continental mass of Europe, Asia, and Africa. A little reflection, however, will show that this great land mass possesses features in strong contrast with the essential unity and homogeneity of the Pacific Basin. The continental mass exhibits the greatest possible degree of heterogeneity. It is possible to subdivide it into units of the most diverse and contrasted characters, some of which, like the pre-Cambrian shields of Fennoscandia, of eastern Siberia and China, and of most of Africa, contain some of the most ancient rock masses on the earth.

Four great periods of orogeny (at least), Huronian, Caledonian, Hercynian, and Alpine, seam the continents, involving vast extents and thicknesses of marine and continental formations deposited throughout the whole of post-Archean time in extensive marine and epicontinental basins (but not in deep oceans), and now included within the boundaries of the composite continental mass.

It is of vital importance to realize, however, that the great land mass in question has not always been so continuous as it is now. Throughout the greater part of geological time the European mass on the west was separated from the Siberian mass on the east by oceanic basins. The sediment-filled trough of the

⁴ A. Obruchev, Review of book by M. M. Tetyaev, "Osnovi geotektoniki" (Fundamentals of Geotectonics), *Izvestiya Akademii Nauk, Geol. Ser.*, No. 3 (1943), pp. 107-27.

Hindu Kush, Tian Shan, and Khirgiz areas must be regarded as structurally the northern extension of the Arabian Sea; a matter of the highest moment in much of the subsequent discussion.

If, as is necessary for the problem immediately confronting us, we emphasize the distribution of the most ancient formations and leave out of consideration, in the initial stages, the younger geosynclinal deposits, the unity of the great continental knot disappears. Certain less apparent, but actually more fundamental, connections can then be traced between units, which, at first sight, do not appear to belong to the general picture.

5. COMPARATIVELY SYMMETRICAL ARRANGEMENT OF EARTH UNITS IN RELATION TO TERRESTRIAL AXIS OF ROTATION

The distribution of the continental masses, certain broad features of their forms, and some of their geological structures require satisfactory explanation. While the shapes are very irregular as regards individual outlines there is a general tendency toward triangular form, with a broad base contiguous to the Arctic Ocean, and a tapering-out in the middle latitudes of the Southern Hemisphere.

If we eliminate from consideration, temporarily, that section of the Eurasian continental mass which separates the European shield from that of Siberia, we have the triangular shape aforementioned more or less completely exemplified by three complex and distorted earth units:

- (1) The Americas, rather perfectly; in spite of the strong kink east of South America,
- (2) Europe and Africa, reasonably perfectly,
- (3) Sino-Indian-Australian mass, much broken and distorted.

A second systematic feature in this distribution is that the northern, basal sections of all the triangles lie roughly on the same broad belt of latitude, with a mean central line situated about 45° north of the equator.

Thirdly, within this zone the central points of the three continental nuclei are situated in longitudes about 100° W., 10° E., and 120° E., respectively. Again the asymmetry of the Pacific Ocean becomes apparent. If it were not for this fact we should have a quite reasonable approximation to a symmetrical distribution of 120° in terms of the longitudinal separation of the major nodes.

Fourthly, in the southern hemisphere the tapering of the continents is rapid and conspicuous; so that this hemisphere, apart from Antarctica, is dominantly ocean-covered.

The Eurafrian triangle tapers off *above sea-level* at the Cape of Good Hope, about 33° S., though the submerged Agulhas Bank carries the line, with continuance of the tapering, to about 45° S.

The Sino-Australian triangle reaches to about 45° S., again allowing for the extension of comparatively shallow sea bed south of Tasmania.

The American triangle *appears* to spoil the general symmetry by running down to a very sharp and strongly recurved point at Cape Horn in latitude 55° S.

As shown later, there are reasons for considering that the southern part of Chile and Argentina may be regarded as a geological unit distinct from the more northerly parts of Argentina. If South America can be tapered off somewhere about the Gulf of St. George at 45° S., its interference with the general symmetry disappears.

Subject to distortions and irregularities, which require explanation, there is, therefore, a rough sort of symmetry in continental distribution, *conforming with the existing axis of rotation of the earth*. This involves as sub-Arctic zone of continental land masses, a sub-Antarctic girdle of ocean, meridional axes for the three continental groups, and a conspicuous southerly tapering of each continental mass.

6. SITUATION AND PERMANENCE OF ARCHEAN SHIELDS

When note is taken of the distribution of the major areas of very ancient geological formations their associations with the continental nuclei becomes very apparent. A large part of Canada, excluding the western parts, consists of pre-Cambrian formations. Their extension southward as a basement under the eastern part of the United States can be inferred.

They reappear in Brazil, and are traceable southward far below the Tropic of Capricorn.

Practically the whole of Scandinavia, Finland, the Ukraine, and surrounding areas are composed of, or immediately underlain by, ancient shield rocks. Considerable areas are present also in the British Isles and in central France. The greater part of Africa is composed of ancient shield rocks.⁵

Eastern Siberia and the adjacent parts of China are built up of pre-Cambrian schists, and constitute one of the most important nuclei of such formations.

The western two-thirds of Australia are occupied by similar formations, thinly covered in places by remarkably undisturbed later sediments.

The important mass of ancient rocks underlying peninsular India and Ceylon, while petrographically forming a unit closely related to the Siberian-Chinese massif on the one hand, and to the Western Australian massif on the other, is conspicuously out of line with those masses, lying far west of the meridian passing through them.

Lastly, much of Antarctica is known to consist of crystalline schists and gneisses strikingly similar to those of the western parts of Australia.

Broadly, then, and subject to distortions and lacunae which must receive explanation, the meridional axes of the continental triangles are marked by ribs of ancient crystalline schists, and Antarctica is composed of similar rocks. India is the only considerable area of similar formations which does not fall within the limits mentioned.

In every instance, also, these areas show every sign of having persisted as

⁵ F. Blodin, *La géologie des mines de vieilles plateformes*. Société d'Éditions Géographiques, Maritimes et Coloniales (Paris, 1936). 301 pp.

continental lands from earliest time, and of having never been involved in major geosynclinal subsidences.

7. ANTIPODAL ARRANGEMENT OF CONTINENTS AND OCEANS

Inspection of a terrestrial globe reveals the striking fact that the continents and ocean basins are *almost* completely antipodal to one another. Of course, since the oceanic area is so much greater than that of the continental lands, there is still a large excess of water.

The same phenomenon can be made more immediately apparent by drawing an antipodal map, such as is shown in Figure 1. To construct such a map, trace to

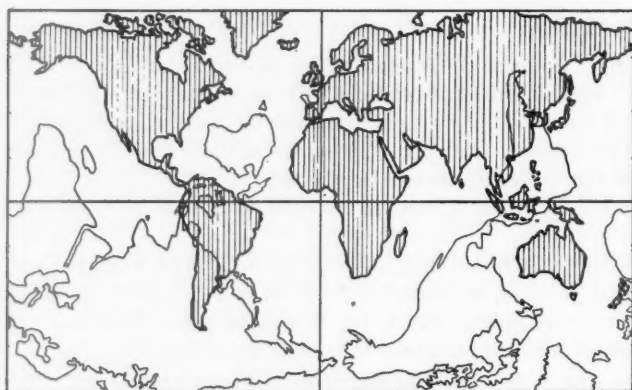


FIG. 1.—Antipodal map of the earth.

outlines of the continents on a sheet of tracing paper, with the 180° meridian centrally situated. Turn the tracing back to front and upside down, and apply to the base map with the 180° meridian of the tracing coincident with the zero meridian of the base map. Trace the outlines again. The two tracings will now be antipodal in position.

Because of the excessive distortion in high latitudes of Mercator's projection, it is advisable to restrict the figure to 70° each side of the Equator, treating the polar regions separately in polar projection (Fig. 2.).

The striking opposition of continents and oceans is clearly brought out by these diagrams. It will be seen that the Eurafican mass in the reversed map falls in the Pacific Ocean of the direct one. Asia and Australia lie respectively in the South and North Atlantic, and the Americas *almost* entirely lie in the Indian Ocean. There is a decided overlap of Patagonia into China; and this discrepancy has to be explained. This is done in the second part of the paper.

Another minor discrepancy is that antipodal Antarctica is a very tight fit in

the Arctic Ocean of the base map. Tentative suggestions regarding Antarctic structure are dealt with later.

Taken in conjunction with all the other objective facts relating to the distribution of continents and oceans, it is impossible to consider that so close an agreement with ideal antipodal symmetry is entirely fortuitous.

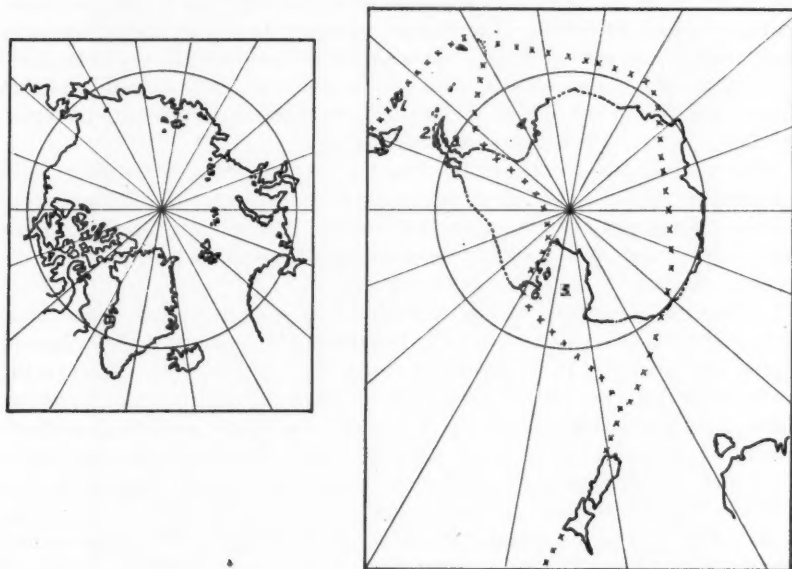


FIG. 2.—Arctic and Antarctic regions. Crosses indicate alternative suggestions (very tentative) for limits of primordial Pacific Ocean.

1. Falkland Islands
3. Graham Land
5. Ross Sea

2. South Shetland Islands
4. Weddell Sea
6. King Edward VII Land

8. TETRAHEDRAL THEORY

The foregoing objective facts fit more or less neatly into the framework of Tetrahedral hypothesis of earth structure which was somewhat extensively canvassed 50 years ago. This elegant and arresting theory does not appear to the writer to have received from geologists anything like the attention it merits. Many of the younger generation may not even have heard of it; so that it appears desirable to outline its main features in summary fashion.

Of all solid figures, that which possesses the *minimum surface* for a given *volume* is the sphere. Hence, any fluid body acted on *only* by the force of surface tension, tends to assume spherical shape. The proviso emphasized in the last

sentence is rarely, if ever, completely fulfilled in nature. Even the raindrop is affected by gravitation and by air resistance which tend to distort it. Most of the non-gaseous heavenly bodies closely approximate the spherical form, though distorted by reason of rotation into slightly oblate spheroids.

If such a heavenly body, originally liquid or plastic, develops a rigid crust and then continues to contract, a new set of conditions is set up. Of all solid figures, that which possesses the *minimum volume* for a *given surface* is the regular tetrahedron, bounded by four equal equilateral triangles. That a *tendency* exists for a contracting sphere of fixed surface to shrink tetrahedrally can be shown by coating a sphere of colloidal material with a rigid shell sufficiently porous to permit *slow* evaporation of the solvent. The writer attempted to demonstrate the effect by filling a metal sphere with steam and cooling it.

Only occasionally are the results of such an experiment really striking; since it is difficult to secure absolute homogeneity of composition, and absolute regularity in decrease of volume, particularly within the time available for a laboratory experiment. Both methods, however, have suggested a *tendency* in the direction postulated.

A moment's inspection of a tetrahedron shows that it possesses four *faces*, each of which is an equilateral triangle. It has four sharp points or *quoins* formed by the concurrence of three adjacent faces. A line from any quoin through the center of the figure passes through the central point of the opposite face: in other words, faces and quoins are antipodally situated. The figure possesses six edges or *dihedral angles* each of which is the common section of two adjacent plane faces.

If such a solid figure is adjusted concentrically to a sphere whose radius is a little less than the distance from the common center of the figure to one of the quoins (Fig. 3.), the four quoins will project above the spherical surface as four triangular pyramids, each on an equilateral small spherical triangle as base. If we imagine the sphere to be composed of water, and the tetrahedron of land, we obtain four "continental" masses, each antipodal to an oceanic sector.

If we assume for a moment that such a state of affairs could have developed in an incipient form in the cooling of an originally viscous, spheroidal, rotating earth, and in the accumulation round the common center of gravity of a spheroidal ocean, it does not seem likely that the generation of the tetrahedron could have been anything but symmetrical with the axis of rotation. This is probably mathematically demonstrable; but the writer is not capable of developing the formula.

It is to be noted that the regular tetrahedron possesses four *triad* axes of symmetry, passing through the quoins and the centers of the opposite faces; and three *dyad* axes passing through mid-points of dihedral edges. From the analogy of a spinning top it would appear that the most stable axis of rotation is the line forming the axis of symmetry of the highest order. In the case of the spinning tetrahedron any one of the four axes could be selected; but once the spin was initiated, it could scarcely be changed from one axis to another. Though all four axes in a perfectly homogeneous tetrahedron are completely interchangeable with

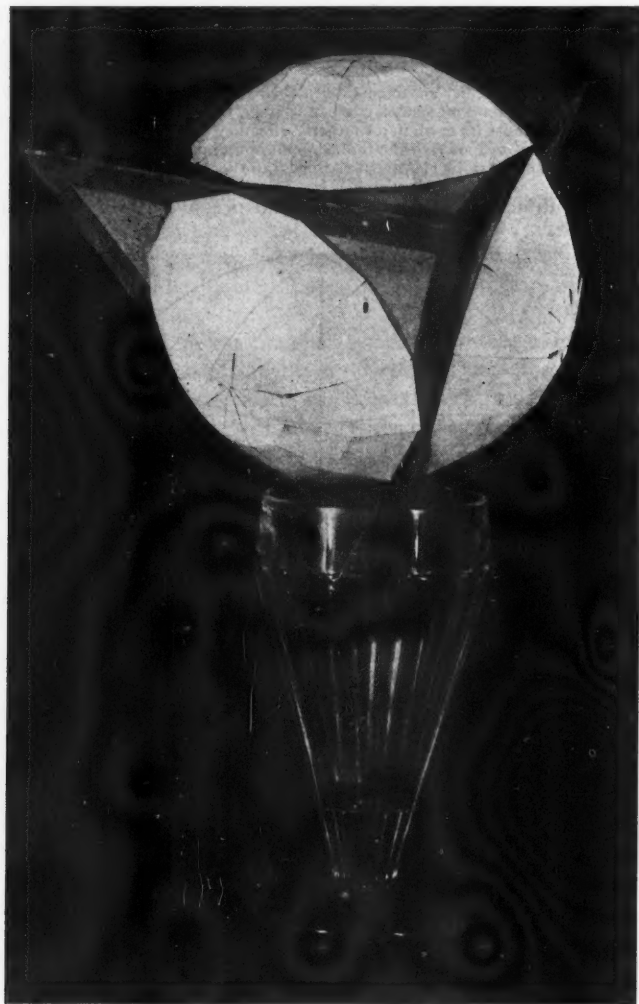


FIG. 3.—Model of tetrahedron and sphere in equipoise.

one another, even a slight degree of heterogeneity would favor selection of one or other of them.

If we assume, further, that this is the case, and also that the solid matter is absolutely homogeneous and absolutely isotropic in regard to every physical and

chemical property, our ideal earth should have the relations indicated diagrammatically in Figure 4. This involves:

- (1) A deep Arctic Ocean,
- (2) Three northern triangular continents, with their centers spaced at longitudes 120° apart, round the circumference of a small circle of latitude $19\frac{1}{2}^\circ$ north of the Equator,
- (3) Each continent must taper off in a southerly direction,
- (4) Each continent is antipodal to the central point of an opposite ocean,
- (5) There will be an Antarctic Continent antipodal to the Arctic Ocean.

The relative dimensions of continents and oceans will depend on the ratio

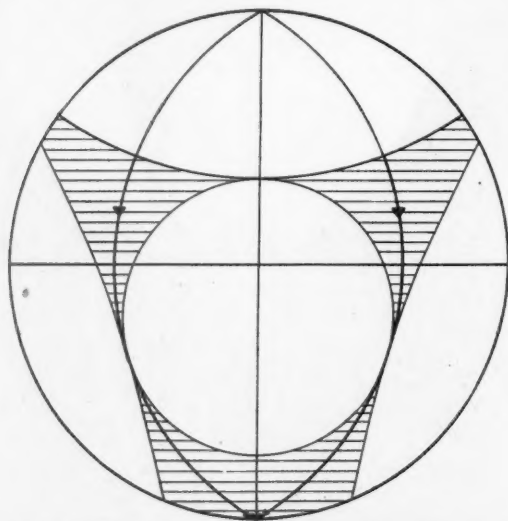


FIG. 4.—Tetrahedron and sphere in equipoise. Stereographic projection. Small black triangles indicate quoin points of tetrahedron inscribed in sphere; therefore, central points of "continental" areas. Apparent inequalities in sizes and apparent distortions in shape of different oceanic and continental areas are due to distortion inherent in stereographic projection.

between the radius of the oceanic sphere (actually a spheroid, nearly spherical), and the distance from a continental quoin to the center. With a suitable choice of this ratio, the southern apices of the continents will reach well below the Equator. Under such conditions the three northern continents will stretch out toward one another, and will be united by sub-oceanic ridges covered by comparatively shallow water, along the lines of the dihedral edges.

From what has been said in section 6, it appears that the existing distribution of the most ancient areas of rock formations is a "colourable imitation" of the state of affairs postulated, though so distorted and so irregular as to be a mere libellous caricature of the ideal arrangement.

If there is anything in the suggestion of a *tendency* toward tetrahedroid de-

velopment, reasons for the discrepancies and an apology for the distortions must be forthcoming.

The first assumption made on page 1990 is sufficiently close to the objective facts as not to need any special pleading.

The second and third assumptions, however, are clearly not applicable to a body like the earth at the present day, and are very unlikely ever to have been fulfilled. While every modern cosmogenic and geophysical theory holds that the earth mass consists of concentric zones of different composition and specific gravity, it does not insist on complete homogeneity and isotropism in each individual shell. That there may have been streaks and patches in the original sial envelope can scarcely be doubted. Hence, absolute symmetry of development can hardly be expected.

Above all, we have the outstanding asymmetry of the unique Pacific Ocean to consider. If this can be explained as an extremely early phase of terrestrial embryology, the residual distortion of continental distribution does not appear excessive. This aspect is dealt with in the second part of the paper.

9. PERMANENCE OF OCEAN BASINS: RARITY OR ABSENCE OF OF TRUE ABYSSAL DEPOSITS ON CONTINENTAL AREAS

If it be granted that the Tetrahedral theory is admissible as a basis for serious discussion, some of its corollaries must receive consideration.

Since, on this hypothesis, oceanic sectors are areas of constant shrinkage and depression, the permanence of ocean basins appears to be an inescapable deduction. The continental quoins are not, so far as radial distance from the center of gravity is concerned, areas of uplift; but they are, rather, points of minimum shrinkage. There is no reason why secondary effects, such as subcrustal variations of temperature, pressure caused by sedimentary loading, crustal folding, movements of magma, and many other factors should not occasionally superimpose actual upward movement. Even apart, however, from any such actual uplift, continued deepening of the facial segments of the tetrahedron, resulting in increased concentration of oceanic waters in the depressions, must leave the primeval quoins progressively higher above mean sea-level as evolution proceeds. Such original projections, then, continue throughout geological time as areas of dominant subaerial erosion. Such erosion, keeping pace with the "uplift" prevents the quoins from appearing, at any stage, as huge excrescences. They are worn down continually to their very roots and reveal the deepest layers of the earth's interior accessible to direct observation. They do not participate to any considerable degree in later oscillations and foldings which affect regions peripheral to them. This is quite in consonance with the universally known facts of the geology of major pre-Cambrian shields wherever they occur.

It is realized that there is considerable diversity of opinion about the presence of representatives of true abyssal red clay formations on continental surfaces. The writer has dealt with this question previously, and has expressed strong doubt

in relation to most of the occurrences which have been claimed as representatives of this class. Until it is clearly proved that true abyssal formations are met with on continental surfaces the matter must be regarded as *sub judice*.

10. WEGENER'S HYPOTHESIS

The Wegener Hypothesis of Continental Drift has been so extensively and exhaustively discussed of recent years that it is unnecessary to remind geologists of its main features. In spite of many important objections in matters of detail, there seems to be no reasonable escape from the view that only a Wegenerian movement is capable of explaining a host of paradoxes affecting the *southern* continental areas.

To the writer it has always seemed that the case for the northern continents is extremely weak, and that most, if not all the similarities of geological structure on the eastern and western sides, respectively, of the northern Atlantic can be explained reasonably well without resorting to extensive continental drift. It is proposed to show later how this may be done by means of the Tetrahedral theory. Any claim of considerable drift of North America and Asia rests on evidence much less objective than that which indicates so clearly the Wegenerian drift of the southern fragments of the pre-Cambrian shield.

It is generally, and apparently rightly assumed that it is some sort of drift toward the Pacific depression which has been the motive force impelling the wanderings of India and Australia in an easterly direction, of South America westward, and of Antarctica southward. In the original Wegenerian concept Africa was regarded as a permanently stable block. There are reasons, however, for the view that this stability is relative rather than absolute.

One of the strongest arguments in reference to the drift of the southern fragments, namely, Gondwana land and its glaciation, is dealt with somewhat more fully in the following section. Here it is desired to emphasize a feature, already well developed by the Wegenerians, namely, the influence of continental drift as it affects Alpine orogeny; but with particular reference to the Australian sector which is, perhaps, less familiar to many geologists than are the manifestations of this action in northern latitudes.

A northerly movement of the African mass, crushing the Mediterranean deposits against the foreland of the Caledonian and Hercynian folds of Central Europe can help greatly to account for the structures of the circum-Mediterranean area.

A much more active and extensive northeasterly movement of the Indian fragment can be visualized even more clearly. The mighty east-west foldings of the Hindu Kush and Himalayas, and the sudden and extraordinary right-angled bend into the line of the Malayan axis can be illustrated almost perfectly by pushing a board through the thick cream on a cheese vat (a homely but instructive experiment).

Quite as clearly the wrinkles north and east of Australia are explained in a

similar way. There are many clues which suggest that Australia's career of drift (no political implications involved) has been even more rapid and extensive. Unlike India, however, it has had no main continental foreland opposing it, although another, highly tentative suggestion is advanced in a later section of this paper.

As there was only one *effective* jaw to the vice the wrinkling caused by the drifting Australian mass failed to produce a counterpart to the Himalayas, and lifted considerably only the mountains of New Guinea.

It may not be widely known outside of Australia that drilling for oil near the mouth of the Fly River of New Guinea has demonstrated the fact that the continental massif of the Australian mainland continues under Torres Strait and well into the hinterland of New Guinea. The Tertiary sediments resting on these continental rocks are undisturbed in this area. Farther to the east late Tertiary sediments exhibit true Alpine fold structures. It is suggested that the marked kink in the mountain axis of New Guinea near the Dutch-British border marks the point where the "keel" of New Guinea has been broken by the "bow-on collision" of the advancing Australian "ram."

The sweep of the plastic sector round the Australian mass like the grain in a piece of pine timber curves round a knot in the wood may be interpreted as an indication that Australia, like India, is an intruding foreign element of earth structure. This is a matter of enormous importance to Australia in connection with the search for oil.

II. STRUCTURAL, PALEONTOLOGICAL AND CLIMATIC UNITY OF GONDWANA LAND

Most of the geologists of Europe, Asia, and North America, though they are of course, aware of the main facts, scarcely realize the extent to which we, in the Southern Hemisphere, have our thoughts influenced or dominated by the extraordinary uniformity of geological formations, of fauna and flora, and particularly of glacial phenomena of about Carboniferous and Permian age constituting the absorbing problem of Gondwana land.

The closest of analogies exists between the geological features of the different elements building up the now isolated fragments of pre-Cambrian shield areas in South Africa, India, and Australia. This similarity is always commented on by geologists from India or South Africa who are visiting Western Australia. With the details of the Brazilian mass we are less familiar; but descriptions of the itacolumites and iron ores of that country might well have been written to describe similar formations in Western Australia.

Without going into details, the reader may be reminded of the close identity of the *Gangamopteris-Glossopteris* flora and of the corresponding marine and terrestrial faunas of Argentina, Uruguay, South Africa, India and Australia. Though little detailed work has yet been done, the general close agreement of the Beacon sandstone series of Antarctica with rocks of Permo-Carboniferous age in Australia suggests that the unknown continent forms part of the picture.

One of the outstanding puzzles has always been the distribution and direction of movement of the ice sheets which produced the glaciated pavements and very thick tillites in all the areas mentioned (Antarctica?). Most remarkable of all is that in peninsular India, in *present* latitude 17° N., ice sheets reached sea-level travelling *from south to north*. Every detail of Indian glaciation finds its counterpart in that of Western Australia, where, again, heavy tillites occur within 17° of the present Equator.

As has been described in great detail by the protagonists of continental drift,

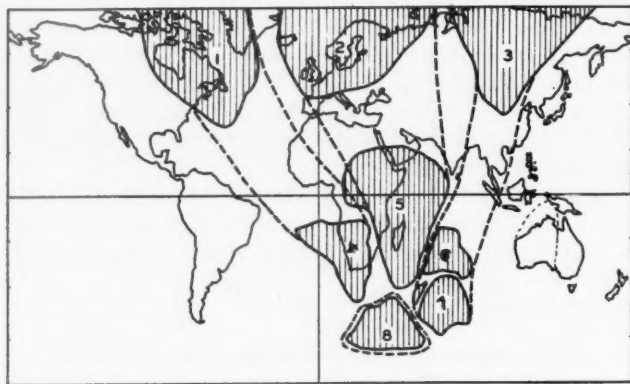


FIG. 5.—Distorted tetrahedral earth. Pre-Hercynian. Slopes of numbers suggest amount of rotation experienced by different continental units in reaching their present terrestrial positions.

- | | |
|------------------------------|------------------------|
| 1. Canadian shield | 2. Scandinavian shield |
| 3. Asiatic shield | 4. Brazilian shield |
| 5. African shield | 6. Indian shield |
| 7. Western Australian shield | 8. Antarctic shield |

these anomalies dovetail with amazing exactness and completeness if, and only if it is assumed that, during Gondwana time, South America abutted against Africa on the west, India and Australia did so on the east, and Antarctica on the south (Fig. 5.).

If it is further assumed that the earth's axis of rotation was then different from what it is now, and that the South Pole was situated somewhere in the region of Madagascar, the riddle of the glacial striae *appears* to have been solved.

Opponents of the Wegenerian hypothesis object, and with good reason, that if the South Pole were situated near Madagascar, the North Pole should have been not far from the coast of Southern California; and that, therefore, we should have reason to expect at least some evidences of polar conditions of climate in Permo-Carboniferous time in the southwestern part of the United States.

It has been claimed by Wegenerian extremists that there is evidence of glaciation in some of the conglomerate beds of western Texas; but this claim seems to

have been reasonably refuted by opponents of the theory. Though the writer has not personally examined the type exposures of the conglomerate in question, he had ample opportunities during 1930 of visiting considerable areas of Carboniferous and Permian exposures in Texas and New Mexico under the guidance of leading American geologists. Though the possibility of the existence of glacial phenomena was discussed with them, and though he was more than anxious to recognize its slightest traces, nowhere was anything seen even remotely resembling the glacial phenomena of Australia, with most of whose exposures the writer is reasonably familiar. Nor are the formations in United States comparable with the tillites of Serra Tartagal on the borders between Argentina and Bolivia among which he spent some time.

On the other hand, all the Texan phenomena of Permian time suggest rather the arid conditions of the desert and not of the steppe type.

It is also pointed out, very pertinently, that the fixation of a South Pole in the Indian Ocean would throw Argentina into rather low latitudes, even if South America were close to Africa on the west. This introduces paradoxes of latitude almost as serious as those which it is the object to eliminate.

Astronomers will not tolerate any suggestion of so drastic a change in the earth's axis of rotation as that mentioned; and apparently geophysicists are in agreement with them.

Lastly, so many of the objective facts outlined in the preceding paragraphs appear to confirm an age-long symmetry of distribution of earth features more or less symmetrically arranged with reference to the existing axis of rotation that it appears imperative to eliminate the necessity for invoking a cosmic cause of such magnitude, affecting the earth so late in its planetary history as Permian time.

Very diffidently the suggestion is advanced that the obvious and admitted center of glacial radiation was not the South Pole of the period; but was the center of a very large and very lofty continental land mass. There appear to be good reasons for thinking that this point may have been considerably farther south than the situation usually assigned to it, and that such a situation would eliminate the climatic difficulties in explaining the glaciation of northern Argentina. Such an assumption involves the abandonment of the idea of the fixity of the African mass, and demands at least some movement of the latter in a northerly direction.

Under the conditions postulated, a major ice cap could easily have developed on the higher lands of the Gondwana continent. Such an assumption appears to be more in keeping with the faunal and floral distribution of the time. Although it is known that a rich and varied marine fauna exists at the present time right up to the very foot of the great Antarctic ice barrier, it is not easy to postulate a completely Antarctic climate for the luxuriant *Glossopteris* flora which produced coal so prolifically during the period. That this flora may have been sub-Antarctic in character, and yet abundant enough to give rise to extensive peaty deposits, has its analogies at the present day in the sub-Arctic peats of northern continental areas.

12, 13, AND 14. REMAINING OBJECTIVE PHENOMENA

The remaining objective phenomena listed in the introduction do not require amplification at this point. They are mentioned so that they may take their place in the theoretical and speculative development of the second part of the paper.

Eras of mountain building have occurred at definite epochs in earth history. It appears that such highly active periods of crustal movement were of relatively short duration, and that they were separated by prolonged eras of crustal stability. The intervals between different orogenic epochs were of different durations, but the alternation of active and quiescent periods is a very conspicuous feature. No theory of earth history which fails to present an intelligible reason for such oscillations is worthy of consideration.

Equally important is the fact that successive orogenies indicate that the zones of weakness have undergone considerable modifications during periods of quiescence. After each manifestation of diastrophism has run its course, and has crumpled and metamorphosed the peripheral regions of the stable earth sectors, the folded areas in their turn tend to become solidified to such an extent that, during the next succeeding orogeny, they behave as stable areas. Blodin⁶ has emphasized this phenomenon. He points out that the primeval shields have progressively expanded in area, as the result of successive accretions of younger formations which have been profoundly altered in the course of mountain-building processes. As each period of activity has developed, its locus of action has had to migrate farther and farther from the original continental nuclei.

Many writers have pointed out of late years the genetic association of granitic intrusions with zones of diastrophism (an excellent recent summary is given by Kropotkin).⁷ The general absence of post-Cambrian granites from shield areas is widely known and has been emphasized by Blodin. In the western two-thirds of Australia, which is a typical example of such a shield, all the numerous granites are pre-Cambrian.

PART II

DISCUSSIONS AND SPECULATIONS

This part of the paper is frankly speculative, and is presented in order to arouse discussion of the highly theoretical and very tentative suggestions advanced. Even if the verdict is an emphatic negative the result can be productive of good so far as geological thought is concerned, since the bright light of searching criticism must illuminate any dark corners filled with uncertainty. The writer desires to emphasize that, while he admits the controversial nature of much of what follows the results are not put forward trivially, but in the good faith of an old man who must very soon quit the stage, and who honestly believes that the suggestions are worthy of serious consideration, and that such consideration may

⁶ F. Blodin, *op. cit.*

⁷ P. N. Kropotkin, "O proeskhodenii granitov" (On the Origin of Granites), *Sovyet Geol.*, No. 9 (1940), pp. 32-43.

lead to at least some new lines of thought in dealing with fundamental geological problems.

The main facts of the Wegenerian Hypothesis of Continental Drift appear to be incontestable insofar as they affect the southern continents and peninsular India. If four of the continental masses consisting of ancient shield formations, with solidified accretions of later age rigidly attached to their margins have moved through distances of from 40° to 60° or more of circumferential arc, how can there possibly be any agreement with the Tetrahedral theory, which reasonably explains the *existing* distribution of land and sea, but which fails lamentably to account for the arresting phenomena of Gondwana land?

It is suggested that the rationalization of this apparently crazy pattern is to be sought in the results brought about by the initial asymmetry of the Pacific Ocean. For this reason the sequence of events deduced from this fundamental assumption may be set down consecutively as follows.

After the original development of the earth mass by any of the methods which have been advanced to account for the genesis of the planet, a period was reached when the first permanent crust was produced. The crust was still thin and quasi-plastic, and was presumably of the composition of sial.

Continued evolution thickened and strengthened the crust, leaving it, however, sufficiently elastic to accommodate itself to the movements of the nucleus.

That the surface was a perfect spheroid of revolution is highly improbable. The crust can scarcely have been in an ideal state of perfect homogeneity and isotropism. Even at this early stage land elevations and water depressions may be postulated, so that some sediments could have been formed among the dominant volcanic accumulations favored by the thinness of the crust.

At this stage the Pacific basin was gouged out, the available evidence suggesting that the action was of a violent nature—a traumatic injury to employ a physiological term.

Either the Darwinian hypothesis of moon birth or the impact scar theory for the Pacific basin requires that the earth must have passed from a truly liquid to at least a virtually solid state externally, otherwise no scar could persist, any more than a stone can leave a permanent dint on the surface of a pond. The objective facts of the existence of the Pacific Ocean, and of the petrographic character of its floor and substratum, point to the same conclusion. Hence the development of the depression must have post-dated the first appearance of a solid crust by a period long enough to enable that crust to attain sufficient stability and thickness to prevent the lateral collapse of the edges into the depression. At the same time the date must have been so early that rigidity of the crust had not developed to such a depth as to prevent its yielding to the force of rotation or of impact. Hence it must have been late enough for the earliest supracrustal formations to have developed, but not late enough for virtual constancy of surface area to have been achieved; and therefore before the initiation of a tetrahedral tendency. Does this in any way simplify the lack of ideal symmetry of the northern continental quoins?

A further highly problematical suggestion presents itself.

If the Pacific basin had been produced according to the Darwinian hypothesis, the tidal stresses involved by the close proximity of the satellite must have been stupendous. They would be powerful enough to create not only oceanic tides of titanic dimensions, but immense crustal tides as well; particularly as a relatively thin and as yet non-brittle crust must be postulated. Is it possible that the intense, universal and *sui generis* metamorphism of the Archean formations is assignable, in part at all events, to such a cause?

A still wilder speculation is suggested by a statement by Japp, quoted by John Read⁸ concerning the origin of life itself. It is pointed out that the synthesis of carbon compounds of high complexity can be carried out in consecutive stages from purely inorganic raw material by means of suitable adjustments of physical environment alone, chiefly temperature, pressure and concentration. Such laboratory synthetic products however, differ from the chemically identical products of plants and animals in being *optically inactive*. Their molecules are optically symmetrical and do not possess the molecular asymmetry of truly organic products. During a cataclysm of such magnitude as the birth of the moon, with its consequential tidal effects might there be developed an asymmetry of such terrestrial forces as gravitation, electricity, magnetism and radioactivity adequate to produce the requisite molecular distortion to enable carbon compounds of suitable composition, produced by inorganic reactions, to pass from the non-living to the vital stage? The wildness of this guess—theory it can not be called by any stretch of imagination—is fully recognized. It appears, however, from the stage of evolution attained by the earliest fossil forms preserved in the rocks, that there must have been an enormously protracted interval between the first appearance of life on the globe and its first recorded preservation in fossil form.

The epoch of formation of the first tetrahedroid tendency must be somewhat later than that of a stage of sufficient yielding of the earth's crust for the initiation of the Pacific basin, whether the latter represents a traumatic injury or not. A fundamental premise of the Tetrahedral theory is that the surface of the solid shall be fixed and not subject to elastic diminution of area as the volume decreases; or, at all events, to a diminution at a much slower rate. It is reasonable, therefore, to believe that a reasonably thick and virtually rigid crust must have developed.

It is suggested that the original Pacific depression was considerably larger than the present one, though, possibly, not so deep. If Wegener's hypothesis is correct this must be so, since he visualizes a Pacific-ward drift of *all* the lands surrounding the depression. In this, the writer thinks an error has crept in, and it is therefore suggested that the limits of the North Pacific have not altered *greatly* since its first formation. Most of the contraction in its periphery has occurred in the South Pacific, defining this sector as extending at least from the South Pole to beyond the Equator (Fig. 6).

⁸ John Read, *A Textbook of Organic Chemistry: Historical, Structural, and Economic*, 2d edit., p. 353. G. Bell and Sons, Ltd. (London, 1941).

Though at the formation of the depression, the earth's crust was just weak enough to permit the scooping-out of the basin, it was on the eve of becoming so rigid that any further decrease in earth volume must initiate the tetrahedral tendency. But for the birth of the Pacific the earth body would have been sufficiently uniform and homogeneous for fairly symmetrical tetrahedroid development; but the titanic cicatrice formed by the Pacific basin threw everything out of balance—and this asymmetry is the root of the whole matter.

It is clear, when the actual distribution of continents and oceans is compared with the ideal representation of Figure 4, that much distortion must be admitted, and if possible accounted for.

In this connection it may be remarked that any deductions based on the

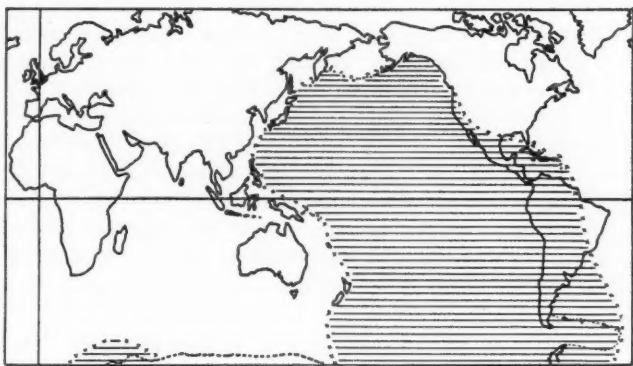


FIG. 6.—Primeval Pacific Ocean (very diagrammatic).

existing areal ratio between sea and land on the earth's surface are beside the point. Great variations in position of land and sea have occurred throughout geological history, and there is absolutely no reason to believe that the conditions prevailing at the present infinitesimal instant of cosmic time are in any way typical.

Several very conspicuous departures from symmetrical tetrahedroid form may be noted.

Firstly, the tetrahedron is inordinately elongated in the direction of the earth's axis of rotation. The Arctic shores of the continents are curiously close to 70° N. Lat. Their *general* conformity with a parallel of latitude is not unexpected as a corollary of the Tetrahedral theory; but the actual position is much too far north. This makes the Arctic Ocean much smaller than it should be. However, the Antarctic Continent also conforms rather closely to 70° S. Lat. so that it, likewise points to longitudinal extension and lateral attenuation of the tetrahedron, which actually tends to become an elevated triangular pyramid.

Secondly, there is a marked degree of discontinuity in the meridional dihedral edges, which is not apparent in the horizontal edges. This is referred to later.

Thirdly, the east-west distribution of the three northern quoins, marked by the nuclei of shield rocks, accords reasonably well with tetrahedroid development, the small discrepancies being accounted for by initial distortion due to Pacific asymmetry.

Fourthly, the overlap of Patagonia and Burma in the antipodal map must be discussed in detail.

The tetrahedron commenced to form with one face Arctic in situation. This, and the selection of the positions of the initial quoins of the northern continental nuclei must have depended on fortuitous circumstances. There is no conceivable reason why a certain longitude should have been chosen for any one of the quoins, but, once determined, the orientation of the figure was fixed.

Once initiated, the development of the northern quoins proceeded as symmetrically as circumstances would permit, producing the nuclei of the three northern Archean shields. The injury caused by the formation of the North Pacific was sufficient to cause some distortion in the fixation of the nuclei, giving rise to the wider east-west interval between the Canadian and Asiatic shields than between the Asiatic and Fennoscandian or between the latter and the Canadian. At the same time the much more profound injury in the South Pacific region may have favored a drawing northward of the zone of continental nuclei, thus accounting for the fact that the center of this zone is 30° farther north than its theoretical position of $19\frac{1}{2}^{\circ}$ N. Lat. This northerly distortion carries with it the relative shrinkage of the Arctic Ocean.

Matters took a far more serious turn in the South Pacific. The immense patch of scar tissue forming the ocean bottom in this region was too "pathologically" weak to take its proper part in the tetrahedroid development. Consequently, *the whole of the southern part of the tetrahedron was congenitally deformed*. For reasons discussed later it is thought that the Pacific scar extended beyond the South Pole, and some distance into the African sector. The fourth quoin of the tetrahedron instead of developing around the South Pole was forced away from its normal position through possibly 40° in the direction of the "sound, normal tissue" formed by the Eurafican dihedral edge, which, be it noted, is antipodal to the Pacific scar.

This distortion carried with it serious congenital spinal curvature of the three dihedral edges which should have been straight and meridional. The final result was of the general nature indicated diagrammatically in Figure 5.

A homely illustration of this kind of distortion can be seen in almost any orchard. An apple or pear, injured on one side by a hailstone or by the bite of a bird or animal, sometimes survives and repairs the wound with scar tissue, which, however, ceased to develop normally. As the fruit continues to *expand* its healthy tissue, while the scar tissue fails to grow, the fruit becomes warped *toward* the scar, and a deformed monstrosity is produced. While, of course, there is no an-

alogy between the development of the organic matter of the fruit and that of the inorganic substance of the earth, the comparison is instructive. In the "healthy" substance of the earth, at the stage of existence postulated, development is by *contraction*, and not by expansion as with the fruit. If, then, a traumatic distortion is produced it should be *away* from the scar tissue, and not toward it as in the case of the apple.

Such a distortion may plausibly account for the initial crowding of the southern quoins and of the curvature of the dihedral angles connected with them.

Progressive cooling of the earth mass produced solidification of ever deeper shells of earth material, each such coating being successively less under the influence of the Pacific scar. The tetrahedral tendency asserted itself as each shell became thicker and stronger, setting up stresses at the roots of the continental quoins. When these stresses attained critical values the drag of the substratum prevailed over the lateral cohesion between the superficial elements and forced the continental nuclei a little nearer their ideal tetrahedral positions. Is it not possible that a general southerly shrinkage of the northern continental quoins in response to such a tendency has produced the more or less east-west tectonic axes which dominate the fold structures of these areas? Variations in solidity, in adhesion between the surface shell and the substratum and other interferences with free movement can explain local anomalies.

During the early stages of readjustment the *lateral* cohesion of the complex southern knot was sufficiently strong to resist the drag of the substratum. It is not unreasonable to suppose that the injury in the South Pacific, being so much more extensive than that in the north, affected deeper zones in the former region, so that the tetrahedral stress was less in evidence.

After the Caledonian adjustments were complete, except for minor local settlements here and there, an era of quiescence supervened, and endured for a very long period during which a still deeper earth shell developed tetrahedral stress. When at last the critical point was reached the depth and thickness of this shell were sufficient to bring about the *dehiscence* of the southern knot. Hercynian earth movements are timed correctly to initiate the dismemberment of the long-established Gondwana continent, each fragment bearing away with it the evidences of the once intimate association between them.

Again the stress spent itself, and stability was re-established.

It is necessary to hark back somewhat, and to deal with a very hypothetical possibility, but one which is believed to be worthy of close scrutiny.

For the Pacific scar to remain as a permanent feature it is essential that the sial crust torn out should have been solid enough to leave the ragged edges of the lacerated wound. It is not unreasonable to deduce that this torn edge would be subject to specially rapid chilling, and would constitute a rim of considerable strength and permanence, opposing a somewhat effective barrier to the free "draw" of material toward the Pacific. The writer is not aware that this suggestion has been advanced previously; consequently the effects of such a factor

may not have been looked for specifically and consciously in the study of the complex circum-Pacific tectonics.

Very diffidently, then, the suggestion is advanced that the complete girdle of active folding surrounding the whole of the Pacific Ocean may be regarded as something separate and distinct from the Alpine orogeny with which it is usually classed; but with which it comes into violent conflict in many critical areas.

In the North Pacific area it has been postulated already that the conditions were not such as to favor a very rapid or extensive continental drift. In late Mesozoic time, however, solidification had proceeded to a depth sufficient for the tendency toward tetrahedral adjustment to make itself apparent in this region. Both Asiatic and North American sectors moved Pacific-ward to some extent, catching the deposits of the geosynclines between the ancient shield nuclei and the resistant rampart of marginal scar tissue, thus developing what is referred to by American geologists as Laramide folding and by Russians⁹ as Pacific folding. From admittedly inadequate study of the literature it appears that there are many points of difference between these structures of the folds of this era and those of the preceding Caledonian and Hercynian orogenies and of the succeeding Alpine one. Can these differences be related to the more linear and less resistant nature of the foreland opposing the thrust?

In the South Pacific conditions appear to have been different, quantitatively if not qualitatively. Of the eastern side of the basin the writer does not possess sufficiently intimate knowledge to speak with any certainty. On the western side it would appear that the rampart of scar tissue can be traced through a line joining New Caledonia and New Zealand, or possibly still farther east through the Fiji-New Zealand line. From New Zealand the line certainly runs southward to Antarctica, and it is suggested that the extremely conspicuous division of Antarctica into two units by Ross Sea on the one side and Weddell Sea on the other actually marks a fundamental structure line of enormous importance. Is it not possible that the strip from King Edward VII Land to Graham Land and the South Shetlands represents a remnant of the marginal scar tissue; while the main mass of Antarctica, including the South Pole itself, is the actual southern quoin of the tetrahedron? Certain it is that the rocks of Adelie Land in the latter sector consist largely of ancient shield gneisses and schists, strongly reminiscent of those of South and Western Australia.

On the South American side it would appear that the extraordinary loop of islands uniting Graham Land, through the South Shetland and Falkland Islands with a point on the mainland about 45° S. may represent the much distorted and displaced scar line of this region (Figs. 2 and 6).

On the Australian side, Australia is still a long way west of the hypothetical scar line, even though, as will be seen later, there has been rapid and extensive post-Laramide drift toward the east (or east-northeast). In Laramide time, then, though Australia unquestionably participated in the general movement, there

⁹ V. A. Obruchev, *op. cit.*

was no effective foreland to produce foldings of the Rocky Mountain type. Such are conspicuously absent from the later Mesozoic formations of eastern Australia. In fact, the evidence concerning the Jurassic and Cretaceous deposits of the Great Artesian basin of Australia strongly suggests that the continent was in tension and not in compression in late Mesozoic time.

After the Laramide contraction had spent itself, apart from local adjustments, stability again reigned until Alpine stresses had accumulated in the deeper substratum. By this time the northern continental belt had become a nearly rigid ring, the dihedral edges uniting the continental quoins acting as well buttressed ribs. Nevertheless, the possibility must not be ignored of a general tendency of the entire ring to work southward toward the zone of theoretical tetrahedral symmetry in latitude $19\frac{1}{2}^{\circ}$ N. The east-west foldings so conspicuous in Europe and Asia appear rather to be associated with movements of the African and Indian masses in a northerly direction.

There seems also to have been a further attempt at east-west adjustment of the gap between the Asiatic and North American nuclei, resulting in intense pinching of the sediments in the zone between the now consolidated Laramide elements and the remnants of the scar ring. The writer is inclined to regard the Japan-Aleutian Island line as an intact position of the scar ring, and therefore comparable with the New Zealand-New Caledonia (or Fiji) line in the south.

American geologists, with their intimate knowledge of the western borders of North America, will be able to differentiate many other possibilities of which the following are a few appearing to be worthy of consideration.

(1) The western part of the Coast Ranges may be the crumpled and altered sediments associated with the scar ring, and the inner folds, including, say, the Coalinga structures, may be the Alpine folds pinched between the scar ring on the west and the rigid Laramides on the east.

(2) The western advance of the continental mass may have caused complete fusion of the true Alpine folds with the scar ring, involving the latter in the former.

(3) The scar ring may have been completely overridden and lost to sight.

(4) The scar ring may be entirely a figment of the imagination; though, until the concept entered the mind of the writer recently he was always puzzled by the intensity of the foldings seen in California, in absence of any effective opposing mass to buttress them on the west.

From extremely scanty knowledge of South American tectonics it is diffidently suggested that the violent westerly drift of that continent has resulted in intense crowding and intermingling of Laramide and Alpine foldings and of scar tissue in the southern part. The extraordinary curvature of the southern tip of South America, and the apparent lag of this part in the matter of westerly drift, as compared with the movement of the broad and massive northerly sector, tempt one to advance the suggestion that both the South American and Antarctic drifting sectors actually broke through and ruptured the scar ring, carrying forward parts of it with them, involved in their Alpine folds, and leaving the inter-

mediate remnant in the form of the South Shetland-Falkland Island loop (Figs. 2 and 6).

The existence of a strikingly similar tectonic loop extending through the West Indies and Yucutan suggests a similar possibility in that region; though the intervention of the Isthmus of Panama introduces complications and difficulties which may be insuperable. At all events, the well known objective complexity of tectonic structure in the Caribbean area invites consideration of the possibility of there being *two* tectonic elements of dissimilar origin, but of superficially similar appearance entangled in the region.

The case of the Australian region appears to be rather more clear. Remembering that tectonic Australia is considerably larger than is indicated by the existing western and northern coastlines, and that it actually forms the floors of the shallow Timor and Arafura seas, one realizes that the northern edge of the Australian massif is closely pressed against the *Alpine* folds of the East Indies from Java to New Guinea, just as is peninsular India against the Himalayas and Malayan mountains. The titanic mountain development of the Himalayan group is readily accounted for by the extremely efficient vice constituted by the plunging mass of peninsular India on the one hand, and the immovable Siberian mass on the other.

Although the plunging Australian mass may be even larger than the Indian one, and although its velocity of movement may be even greater, the absence of any effective buttress has enabled it to drive its "bow-wave" forward without uplifting the folds into high mountain ranges.

That New Guinea belongs to the main Alpine system is unquestionable. The impact of Australia has broken the back of this very massive island unit, and caused the kink near the international boundary line. Australia itself did not come off scatheless in the encounter, as the local distortion of Cretaceous sediments in the Broadsound area of Queensland suggests. This explanation appears preferable to regarding the folds in question as very local manifestations of Laramide activity.

North and east of New Guinea, however, the tectonic structure becomes extraordinarily complicated. While there is no such conspicuously marked loop line here as those of the South Shetlands and West Indies the confusion of axial structural lines is even greater. There can be little doubt that the New Ireland—Solomon Island axis belongs to the scar line, but there is an inextricable tangle of intersections. Again it is suggested that if the concept of a fundamentally distinct and relatively ancient circum-Pacific scar line is tenable it is capable of providing a key which ultimately may assist in resolving the tangle.

One is tempted to embark upon still other explorations of possibilities inherent in these ideas. Thus, it seems clear that peninsular India, though obviously one of the fragments of Gondwana land, has embarked on a career different from those pursued by the other three major sectors. In drifting directly into the main-

land of continental Asia it has plowed its way through the deep geosyncline, which, from the earliest dawn of earth history, separated the Asiatic and Fennoscandian continental nuclei. Again it must be emphasised that the Caspian, Turkestan, Persian Gulf sector, while now well within the limits of the land area of Asia, was, functionally, throughout geological history the northern part of the Indian Ocean. Much of the mightiest mountain mass on earth is situated where India has plunged in among the deposits of this deep geosyncline, and driven them before it in its endeavors to reach its allotted station as part of the Asiatic-Australian dihedral edge. In this endeavor it has been frustrated by the stupendous mechanical work of building up the mountain masses. While Australia is reasonably close to the line which one may suppose it should eventually occupy in the complete tetrahedral symmetry, India still lags at least 40° behind.

Clear as it is that Australia has drifted east or east-northeast until it has squeezed New Guinea against the scar line of the Pacific, the absence of any pronounced Laramide and Alpine foldings in continental Australia suggests that, throughout most of its long journey of drift, it has had an unobstructed course. If it is correct that, once the approximate tetrahedral symmetry is restored, the impulse toward continental drift will come to an end, the wanderings of Australia may be almost finished. That this may be the case is at least suggested by the contours of the ocean floor in the New Zealand-Kermadec Island area. Along this line there exist some of the deepest chasms in the ocean bottom. Their form and direction strongly suggest that they are the result of tensional stress rather than compression. If this be so, it follows that, instead of there being a tendency for the Australian mass to continue its career Pacific-ward, the scar line in this sector is actually being caught up in the tetrahedral readjustment, and is being drawn west to help to build up the outer part of the Asiatic-Australian dihedral edge.

It is to be noted that a similar tendency may be present in the North Pacific, where, also, abyssal oceanic depths form a line parallel with the coasts of Japan.

The Antarctic Continent, like Australia, seems to have reached its final resting place. Probably, like Australia, it never encountered resistance enough to give rise to excessive mountain foldings, though, if it is correct that it has impinged on and broken through the scar line in the South Shetlands area, this may have to be modified.

South America, like India, has failed to arrive at its logical destination, which should bring the oldlands of Brazil south of the Canadian shield. It has been suggested above that its westerly drift has been hindered very considerably by the presence of a strong part of the scar ring around what was the southeastern edge of the Pacific depression. At all events, South America as a whole is about 40° too far east to play its proper part in the development of ideal tetrahedral symmetry. It should be noted that if South America had come into meridional relation with the Canadian quoin, the overlap in the antipodal map (Fig. 1)

would bring Patagonia into the Turkestan-Caspian triangle, which, as already stated, is functionally the northern extension of the Indian Ocean. The fault of the asymmetry in this pattern rests with South America.

An objective fact of major importance which is not included in the list on a subsequent page, and for which an immediate explanation is not forthcoming, is the existence of a break in continuity of the meridional ribs of the fundamental tetrahedron composed of ancient shield formations. Theoretically the dihedral edges of the continental nuclei should be composed of such formations, and should be buttresses of great solidity and permanence. On the earth we find that, in every instance, such buttressed ribs are conspicuous by their absence from the sector between the northern quoins and the southern apices of the triangular continental nuclei.

Moreover, there appears to be no evidence whatever of even a remnant of their presence in such situations, even at the inception of tetrahedroid development. The broad zone stretching through the Antillean area, the Mediterranean, and sweeping down through the Persian and Turkestan regions to and through the East Indies (neglecting peninsular India, which may be regarded as a trespassing unit), appears to have been a permanent geosynclinal sector throughout geological time, a role which it continues to play to a more or less marked degree.

Is there any conceivable reason why such a zone of weakness should develop and persist during tetrahedroid deformation?

It may be mentioned, though very little importance is attached to the particular observation, that, during the writer's very early and crude experiments with steam-filled metal spheres, there was in one case collapse of the figure and crumpling of the meridional edges, more or less reminiscent of the type of weakness here visualized. The test was quite inconclusive, since the sphere in question was built up of lunes of thin metal, dished and curved, and soldered along the edges. There was therefore an entire absence of even the semblance of homogeneity of structure which must be postulated for the earth body.

Possibly mathematical investigation may show that the tetrahedral quoins, consisting of the three dihedral edges converging to a point, may form mechanically sound and rigid structures which refuse to become distorted; while the single dihedral edge uniting any two adjacent quoins *may* be mechanically weaker, and prone to collapse. If such a tendency exists it would certainly be accentuated by the axial attenuation of the figure which converts it into an elongated triangular pyramid.

Even without attenuation, however, the fact is that the three northern dihedral edges, lying in a plane of rotation, would be stressed differently from the meridional dihedral edges, which are transverse to the direction of rotation. This *may* be why the latter edges show weakness while the former do not.

In this connection it may be pointed out that the tidal effects must have been much more powerful in the earliest stages of tetrahedroid development, while the mass of the earth was still far less consolidated than it became later. If, as Dar-

win's results seem to indicate, the moon's distance at that epoch was far less than it is now, tidal stresses alone may have been adequate to produce the weakness.

One is tempted to explore the possibility of a centrifuge effect due to earth rotation; but an angular velocity of only 15 seconds of arc per second of time appears totally inadequate to produce such a result. The angular velocity in a cream separator necessary to separate butter fat from water is many thousands of times as great. Is it possible that, infinitesimal as is the centrifugal effect of earth rotation, it may be integrated to attain a finite value in the course of what is potentially infinite time? Moreover it is certain that diurnal rotation was originally much higher than it is now, though it is inconceivable that it ever approximated to that of a mechanical centrifuge.

If a centrifugal effect is admissible, the result must be visible in the thinning of the sial crust toward the Equator, and the bringing of the underlying sima layer closer to the surface. This should be indicated by systematic variations in the compositions of igneous rocks, particularly volcanic ones, in the equatorial zone; a variation which, so far as is known, has not been established.

One last possibility must be mentioned. The belt of weakness is not exactly equatorial; it is farther north in the Eurafrian sector, antipodal to the Pacific, than it is in the Pacific area. As the line approaches the Pacific it actually passes into south latitude. Is it possible that the zone *was* actually equatorial at the date of the moon separation (on Darwin's hypothesis), and that some minor irregularity in the separation of the moon mass threw the earth figure into a state of unbalance, necessitating a slight adjustment of the axis of rotation?

This speculation—admittedly a very long-range shot—would fit in quite neatly with the apparently objective fact that the earth lesion caused by the South Pacific seems to have been considerably more severe than that of the North Pacific; a possibility which has been evoked already to account for the assumed congenital deformity of the tetrahedron.

If the results of the foregoing discussion are accepted, even in broad principle, they may apparently contribute to some of the other geophysical difficulties which have long been stumbling blocks in the domain of geological theory. One of these outstanding difficulties is that of accounting for the energy relations exhibited by the periodically recurring eras of orogenesis. These movements involve vast expenditure of dynamical force to produce the mechanical deformations observed, and probably even greater amounts of energy in the form of heat and molecular condensation essential to account for the igneous injections and rock metamorphism so intimately associated with mountain building.

If the primary speculation of early asymmetry rests on firm foundations—and the malformation of the Pacific Ocean is an unquestionable fact which must be explained somehow—the remaining links in the chain form a logical sequence. It has always appeared to the writer, that, convincing as was the evidence for the Wegenerian hypothesis as applied to the southern continents, it lacked the motive force necessary for its realization.

Initial traumatic deformity engendered in an attempt to produce tetrahedroid symmetry, followed by the re-assertion of the symmetrical tendency as deeper zones, unaffected by the surface injury, exerted their stress upon the deep-seated roots of the continental nuclei, makes available at once a reason and a supply of energy adequate to account for continental movement, for recurrent diastrophisms, for igneous injections even if they involve extensive melting of great masses of sediment, and for the processes of metamorphism.

The not unreasonable suggestion of the long-enduring existence of a circum-Pacific scar may provide an escape from the dilemma caused by the extreme complexity of the tectonic features of such critical regions as the East and West Indies and Cape Horn.

It is not considered for a moment that these factors are the only ones involved, and that they are exclusive of the many other causes which have been adduced to account for the major phases of dynamical geology. Unquestionably the energy effects of radioactivity must play a very important role in all such processes. In fact, there seems a very high probability that there still remain unconsidered effects in geophysical history which, when glimpsed, will provide short cuts to the understanding of terrestrial embryology.

The well debated effects of sedimentation in geosynclines, redistribution of geoisotherms, and many others, unquestionably contribute to the ultimate integration of geodynamical efficiency.

CONCLUSIONS

The sole justifications for excursions, such as the present one, into the realms of pure speculation in geology is that the conclusions arrived at should not be inadmissible within the limits of the fundamental laws of physics, chemistry, and mathematics which ultimately control all the phenomena of non-living matter. It is essential also that the suggestions made should direct the attention of scientific investigators to the phenomena which are under observation by them. In a scientific investigation it always happens that there are details which appear trivial or extraneous when viewed only from the conventional standpoint. When, however, special attention is focussed on them owing to a suggested change in the point of view it is often found that such details assume an importance and a perspective not previously realized.

It is therefore suggested that investigators engaged in the study of major tectonic problems everywhere, but particularly in circum-Pacific areas, should give some special thought to the possibilities here advanced. If it is found that the suggestions are in conflict with objective fact they will be permanently eliminated, and need not again be considered by those who are delving into ultimate mysteries. If, on the other hand, phenomena otherwise unrelated become coordinated, the crude speculations here advanced can be modified and shaped more accurately to portray the real facts.

It is especially suggested that investigators should test critically the possibility of the existence of a circum-Pacific fundamental structure in relation to

the conflict between Alpine folds and those circum-Pacific folds which intersect them so conspicuously in the East and West Indies, and possibly in the Cape Horn region.

A second "long-range" objective may possibly exist in relation to the nature and origin of the broad belt of long-persisting earth weakness breaking across the meridional continuity of the main ancient shield areas, generally a little north of the Equator. In this connection the bare possibility should be canvassed of the

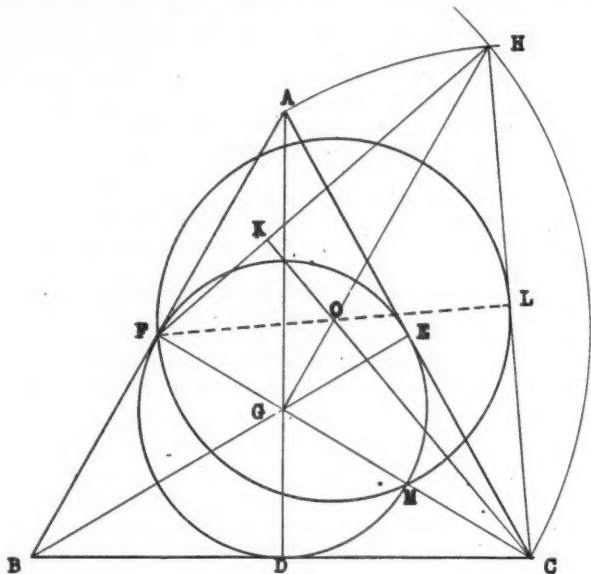


FIG. 7.—Geometry of tetrahedron and sphere.

existence of a centrifuge effect, bringing about an equatorial thinning of the sial envelope, and a decrease in depth from the surface of the upper boundary of the underlying sima.

If there is any semblance of reason in the speculations it appears that there should be scope for mathematical treatment of the possibilities and consequences of initial Pacific distortion, tetrahedroid development, congenital deformity of the tetrahedroid figure, its dehiscence during Hercynian time, continental drift, and the release of latent kinetic energy thereby. Mathematical analysis of the effects of tidal retardation on a tetrahedroid figure rotating about one of its trial axes of symmetry may be found to be a profitable exercise.

SUPPLEMENTARY NOTE. GEOMETRY OF TETRAHEDRON

Figure 7 provides the data for the case of a tetrahedron and sphere in equipoise, as illustrated in Figures 3 and 4.

ABC is the horizontal, north polar face of the tetrahedron, G being the central point of the equilateral triangle.

CPH is the central vertical plane of the tetrahedron rabbetted round the common section CF into the plane of the drawing; so that H is the south polar quoin of the figure. This shows that O is the common center of the figure. O , of course, lies vertically below G in the three-dimensional figure.

A sphere with center O and radius $OF = OL$ touches all the dihedral edges of the tetrahedron at their middle points, that is, passes through the ends of the cubic axes.

In the three-dimensional figure the light circle with O as center and OF as radius is in the vertical plane at right angles to the plane of ABC ; FGM is the common section of the circle and plane. Since the section of a sphere by a plane is a circle, therefore, the heavy circle with G as center and GF as radius is the trace of the sphere on the horizontal face of the tetrahedron, that is, is the outline of the "Arctic Ocean" of the figure. The triangular areas with curved edges AFE , BDF , CED , are the projecting portions of the three "continents" involving the face ABC of the tetrahedron. These "continents" just touch one another at the angular points of three basal curved triangles, at the points of emergence of the cubic axes.

The angle GOK = the internormal angle between adjacent tetrahedral faces, by calculation $109^{\circ}28'$. This is equal to the arc of the great circle of the sphere between the South Pole and any one of the remaining quoins, so that the latter lie on the small circle of $19\frac{1}{2}^{\circ}$ N. Lat.

The angle OFG = latitude of the face ABC . By calculation this is $35^{\circ}16'$ N. Lat.

Since the southern extremities of the northern "continents" are midway between their own centers and the center of the "Antarctic Continent," they reach Lat. $35^{\circ}16'$ S.

Under these conditions the area of each of the oceans is one sixth of the area of the surface of the sphere, or the four oceans occupy two thirds of the surface, and the continents one third.

RECENT TRENDS IN GEOLOGICAL-GEOPHYSICAL EXPLORATION AND METHODS OF IMPROVING USE OF GEOPHYSICAL DATA¹

R. CLARE COFFIN²
Tulsa, Oklahoma

ABSTRACT

Since 1942 the use of gravimetric methods has increased in the United States approximately 200 per cent, seismic methods 50 per cent, core drilling 100 per cent, and the magnetic investigations 70 per cent. The impact upon geological thinking because of this continued increase of geophysical effort is discussed. Full advantage offered by these methods and combinations of methods is not being made. A better use of the low-cost methods is pointed out. With the tremendous increase in the use of the gravity method there has not been a corresponding improvement in the proper understanding of its possible use and its limitations. The gravity method is discussed in some detail. A tremendous improvement in our geological thinking and a better use of geophysical data are possible by an education of "district" or "grass-root" geologists in geophysical concepts and a freer use of this information. A trend in this direction is noted, but the need of an accelerated move in this trend is emphasized.

INTRODUCTION

The geological staffs of oil companies were so depleted during the war that a minimum of work was devoted to the development of new geological ideas. The need of new reserves was never greater and extra effort was put forth to make new discoveries; but this special effort included not new procedures but a greatly increased use of existing techniques, with expenditures in geophysical exploration greatly increased, as the following figures show.

Approximately 150 gravity meters were in operation on oil exploration in the United States in November, 1945, an increase of 200 per cent over the activity of 1942. During this same period the seismic units increased to 324 (a 50 per cent rise), core drills to 52 units (a 100 per cent increase), and magnetic exploration 18 units (a 70 per cent increase). In fact, the geophysical exploration in some areas was limited only by available men and equipment. A noticeable decrease in geophysical exploration is recorded in the first 3 months of 1946, but this exploration effort probably will remain at approximately its present high level through the present year.

In passing, it is of interest to record that similar exploration increased tremendously in Mexico and South America during a similar period. Three service companies offering seismic and gravimetric exploration in foreign lands offer an index to this increased activity. This group alone reported a total of three seismic units and one gravity-meter unit in operation in Mexico and South America in 1942, and 21 seismic units and 10 gravity meters operating in 1945. This activity represents approximately 30 per cent of the geophysical exploration being conducted in these countries.

¹ Read before the Association at Chicago, April 4, 1946. Manuscript received, June 10, 1946. Published by permission of Stanolind Oil and Gas Company.

² Geophysical coordinator, Stanolind Oil and Gas Company. The writer is indebted to G. L. Taylor and W. R. Syre for the computations used and for helpful suggestions. For the numerous drawings, he is indebted to several members of the geophysical and geological staffs.

The development of an air-borne magnetometer for war purposes and its adaptation to general magnetic mapping is a revolutionary advance. The use of such equipment will stimulate magnetic exploration generally and make feasible the investigation of areas not accessible by ordinary means of travel.

Other geophysical activity at the beginning of 1946 includes four companies offering soil-gas analysis and one analyzing the fluorescence of soil samples as a means of exploring for petroleum direct. At least two companies report the use of electrical methods during the period.

Although there were few new developments in geological methods during this period, some progress can be reported in the application of old techniques to new problems. The renewed interest in the Rocky Mountain states brought many geologists to this province to do surface mapping and thus restore an art all but lost to our profession. The use of insoluble residues in the pre-Permian beds of West Texas has been successful in breaking down the Ellenburger formation into several recognizable units. Improved methods of logging shallow core holes by electrical methods have made core drilling feasible in areas which formerly could not be economically explored because of the lack of recognizable shallow markers. New logging services include new procedures and improvements in the quality of data provided by established methods. Gamma-ray logging has become an accepted practice in some areas. A method of determining dips in drilling wells by electrical methods was perfected and made available to the industry in 1943 and radioactive bullet markers used in 1944 assisted geologists in making precise the location of pay sands in deep wells. Seismic and gravity methods were adapted to work in the open ocean during the war period, and exploration of parts of the Gulf of Mexico is now under way.

Studies neglected in recent years include the origin of sands, analysis of waters and studies of temperature gradients. The geologist who undertakes any of these special studies finds himself at a disadvantage because of the lack of material in the provinces best suited for investigation. The question then arises as to the limits we should go beyond those generally imposed on a drilling well to obtain data on all formations drilled. Every wildcat well is a research project and within certain limits should be so treated. The idea suggests itself that some cooperative scheme be initiated whereby information be obtained from all wells drilled within a selected area and thus provide data from numerous strata, making possible exhaustive geological research. The problem invites discussion not possible in this paper.

An examination of our geological and geophysical expenditures will focus attention on that part of our exploration effort which is of maximum concern. The exploration budgets of at least three companies whose geological and geophysical expense exceeds \$5,000,000 yearly carry items for geophysical expense in excess of total geological expense in ratios ranging between 5 to 1 and 10 to 1. Obviously, the geophysical expenditures which have continually increased for the past 10 years will remain, and properly so, at a high level indefinitely.

Analyzing the results of this tremendous effort in acquiring new data of use to the geologist, we should have cause to wonder how exhaustively this information is being used. Little, if any, geophysical data can be analyzed to the point where the original interpretation can be made, conclusions drawn, and the geophysical records put aside. The problem becomes stupendous when we realize that almost any well drilled necessitates a reconsideration and a re-study of the original data; in fact, the geophysical data in some areas require a certain amount of exploration by drilling before an intelligent interpretation can be made.

The purpose of this paper is to inquire into certain phases of the progress of geological thinking during this period in which geophysical expenditures have grown to such high levels. Have we been sufficiently alert to the advantages offered by the tremendous acceleration in the rate of supplying data to the geologist? From such an analysis we see the need of a definite trend in geological procedure and thinking to maintain a well balanced exploration program.

We have been continually asking for an exploration method by which to explore for petroleum direct. Certain methods working to this end have not yet reached the stage where they are satisfactory. Until a direct method completely satisfactory is developed, the geologist is challenged to make better use of the things now at his command.

At the risk of being considered out of place in presenting these ideas before a geological group, rather than before a geophysical group, and at the risk of being considered elementary, the writer presents certain phases of geological-geophysical thinking which may seem trite but which, however, are fundamental. Such a repetition will attempt to prove that the geologist must have a better understanding of geophysical concepts if he is to make better use of existing information.

To project geological interpretation beyond the initial and apparently obvious interpretations made by the geophysicist at the completion of this original work involves geological thinking of the highest order. To construct a map from the initial seismic data, or to draw circles on gravity maps outlining anomalies, is only the beginning of geophysical interpretation. The geological aspects of only those phases of geophysical-geological interpretation which have not received their proper attention will be discussed.

COORDINATION OF GEOPHYSICAL EXPLORATION

No geophysical surveys employing the commonly used devices fail to contribute data by which the geology of an area may be better understood. The question may be asked, "Does the information contribute enough to be worth the cost of obtaining it?"

Any contemplated program of geophysical exploration involving one or more methods must be based on the general approximation that a gravity survey costs per unit area ten times that of a magnetic survey, and a seismic survey ten times that of a gravity survey. The cost of core drilling ranges so much that no figure

can be given which would be meaningful in this cost schedule. In general, it is more expensive per unit area explored than other methods and should be used only in special cases where other methods have failed.

If the geophysical characteristics of an area lend themselves to exploration by low cost methods, a progressive order of work from the less expensive to the more costly can be used with distinct advantage in the ultimate cost of the work. Frequently a consideration of more importance than the ultimate cost is the timing of the exploration effort and the speed with which information is made available by the low cost methods. The question of which technique is best suited for any given area may require a trial, but within certain limits the effectiveness of some methods can be predicted; this will be discussed later.

Rightly used, a series of geophysical surveys from the less costly to the more costly will progressively narrow the area of interest. Under such a program the value of any one survey is difficult, if not impossible, to determine—all combine in producing a finished product.

The writer takes violent exception to the thought implied in many analyses of exploratory effort, wherein a series of discoveries is listed the the methods responsible for each discovery. If these analyses reflect accurately the methods employed, it is evident that the geologist frequently is not using the several geophysical techniques in proper coordination. Under ideal conditions the several methods should not be used competitively but each should contribute an essential part in the program. A simple statement of an actual case serves to illustrate the point.

A magnetically anomalous trend supported by a limited gravity survey provided the incentive in leasing a 50,000-acre block so far ahead of the exploration for the area that the cost per acre was one-fifth the going price for wildcat acreage being paid in neighboring counties. Core drilling followed in two selected areas in the block. In one area a map of a shallow marker was sufficiently interesting to justify a well which discovered a new field. An anomalous picture was obtained in the second area by core drilling. A limited amount of seismic work was then completed, a second well located, and a second field discovered.

The area involved parts of Barton County, Kansas, and the two pools discovered were the Richardson and South Ellinwood. The original cost of the block was 10 cents per acre and the over-all time from the beginning of the work to the time when the second prospect was ready for drilling was one year. The records mention that one pool was discovered by core drilling and the second by seismic methods—what an injustice to the exploration effort!

The fact that additional oil pools have been since discovered in the area covered by the original surveys but not predicted by the original work does not detract from the methods or from the coordination employed. The original discoveries provide the geological characteristics of the area and the focal points from which further exploration could be planned in an orderly manner at a minimum expense.

The simultaneous interpretation of two or more sets of geophysical data has

many obvious advantages. Special advantages of such a procedure are found in areas where the data from any one method are inferior in grade, or the results inconclusive. In making interpretations of several sets of data, it is vital to have well in mind the probable geological circumstances responsible for each. Under such conditions two sets of geophysical data can be made to complement each other.

Magnetic and gravity exploration in West Texas and adjoining New Mexico are both effective, but for different reasons. The magnetic disturbances are related to the structural features of pre-Cambrian rocks, and the local gravity anomalies are due largely to the density contrasts between the redbeds section and its associated salt with the "lime" below—two horizons which may be several thousand feet apart.

The mapping of the surface formations is justified even where the information itself does not have impressive significance, but when taken with an adequate gravity survey may be of much value. A single isolated outcrop of pre-Tertiary beds in the Tertiary-covered areas of the Rocky Mountains may be of inestimable value in helping in the interpretation of a regional gravity map. A few strategically placed core holes, or a single seismic traverse of limited extent with a regional gravity survey may serve the same purpose of predicting the general structural picture which can be further explored in an orderly and well planned manner with a minimum of expense.

In dealing with several sets of geophysical data, each inadequate in itself to provide a solution to the problem, the geologist is faced with the same problem confronting a doctor in diagnosing an ailment. Two different symptoms are many times more valuable in drawing the proper conclusion than one, and three are better than two. The sum total of the value of these clues may not be an algebraic sum but some larger value.

A series of marginal seismograph traverses obtained in an area where salt domes are expected may be combined with an inconclusive gravity survey to suggest whether or not a salt intrusion is to be expected. Again, a marginal seismic survey can often be combined with a marginal gravity survey to change an area of questionable value into one having a third- or second-class rating which demands further exploration.

Many instances have been noted where complete gravity surveys have outlined the presence of deep-seated features which the original seismic exploration failed to find because of inadequate exploration. Under such conditions special effort and special techniques should be employed to give proper attention to the area. Let us examine two areas where two or more sets of data can be used to the mutual benefit of both methods.

The outlining of two gravity anomalies in Figure 1-A is clearly justified at points *A* and *B*. Subsequent exploration has shown both to be structurally of interest. A magnetic map (Fig. 1-B) of the same area outlines a magnetic anomaly at *A* but none at *B*. Inasmuch as structure of the limestone strata at 4000 feet is

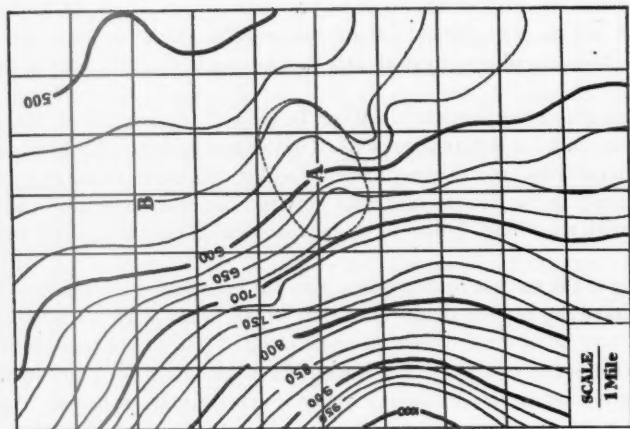


FIG. 1-B.—Magnetic contours of area in West Texas; outlined in Figure 1-A. Contour interval, 25 gammas. Note magnetic anomaly at *A* and absence of any at *B*. Pre-Cambrian formation which produces this anomaly is known to be 3,000 feet deeper at *B* than at *A*.

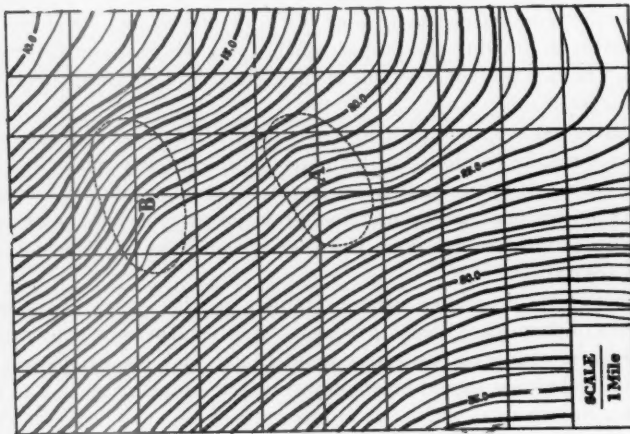


FIG. 1-A.—Gravity contours of area in West Texas; Contour interval 0.5 milligal. Anomalies at *A* and *B* produced largely by density contrasts between redbeds and limestone at depth of approximately 4,000 feet. Both anomalies outline known structures.

responsible for the gravity anomalies and the pre-Cambrian formations are responsible for the magnetic effects, it follows that the pre-Cambrian is much deeper under structure *B* than at *A*. This conclusion has been confirmed by drilling which places the pre-Cambrian more than 3,000 feet deeper at *B* than at *A*.

A prominent gravity anomaly in a Tertiary-covered area is outlined in Figure 2. The area is characterized by much pre-Tertiary topography which permits the

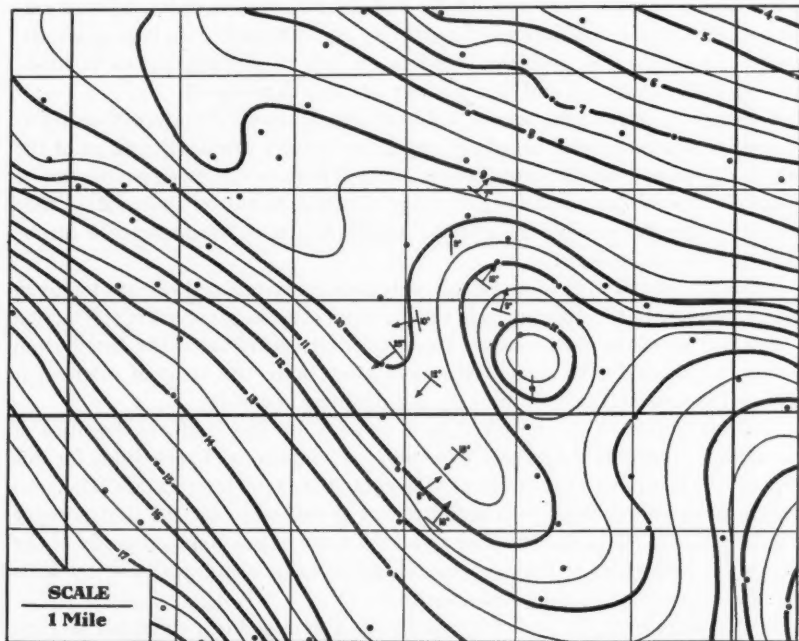


FIG. 2.—Gravity anomaly in Tertiary-covered area of Rocky Mountains; contour interval, 0.5 milligal. Area characterized by pre-Tertiary structure and topography either of which might produce anomaly. Dips from limited seismic exploration confirm presence of shallow structure rather than pre-Tertiary topography.

possibility that the gravity meter mapped only topography. A few well placed seismic dips eliminate this possibility. Again, the shape of the gravity anomaly indicates the beds providing the density contrasts are shallow. The feature was explored by a core drill hole less than 2,500 feet deep.

GRAVITY SURVEYS AND THEIR INTERPRETATION

The unprecedented increase in the use of the gravity meter in the last 4 years calls for a critical study as to the methods of conducting these surveys and the

interpretation of the data. This type of exploration will doubtless repeat the mistakes of seismic exploration where conclusions were made erroneously with inadequate control and too little, or no, attention was paid to anomalous data just because we thought them incorrect.

Emphasis is given to the discussion of the low-cost geophysical methods not because they are the most important—they are not—but because the data provided by these methods have been so mistreated and so misunderstood that an explanation of some of their possibilities and limitations is in order. Up to a certain point the problem of interpreting gravity and magnetic data is geophysical; beyond this point the problem becomes geological, demanding an intimate knowledge of the regional and local geology of the area involved.

Although it is true that several different distributions of materials of different density can be devised to satisfy any given gravity profile, the range of the geologically acceptable circumstances which will provide the given profile can be limited. It is possible to restrict this range of probable answers well within that commonly thought possible by a proper application of techniques which can be developed by the geologist.

Although the gravity meter measures the total gravitational effects at a given point, those due to the differences in the densities of rocks involved in the section to be drilled are of the most concern. Inasmuch as irregularities in the distribution of these densities due to structural deformation mark the areas of interest, it becomes fundamental to determine these differences in density.

A direct approach to the problem is possible by the study of densities of cuttings and cores. Much has been said as to the limitations of such study for this purpose; the fact remains it can be used to contribute vital information. The need of such an extended study in a regional way is necessary for the best possible understanding of the problem. After 3 years of more or less constant study of the density characteristics of cuttings, cores, and outcrop samples, the writer finds that new data are continually full of surprises.

With a knowledge of the density contrasts determined in a columnar section, the gravity effect of any part, or all, of the sedimentary section can be determined in any given structural deformation. Given the problem of exploring any area, the computed effect of the minimum-sized structure of interest can be determined. If the computed effect is measurable by a gravity meter, the problem becomes workable if a pattern of observations suitable for detection of such a structure is selected.

Fortunately, the whole scheme is subject to a fairly rigid test. The gravity anomaly of a known structure well controlled by subsurface data can be computed from the density data at hand and checked against an actual field survey. If the comparison is proved satisfactory, confidence is established in the method and the possibilities of using the gravity meter effectively. Measured by such standards numerous gravity surveys fall far short of accomplishing the thing they were designed to do.

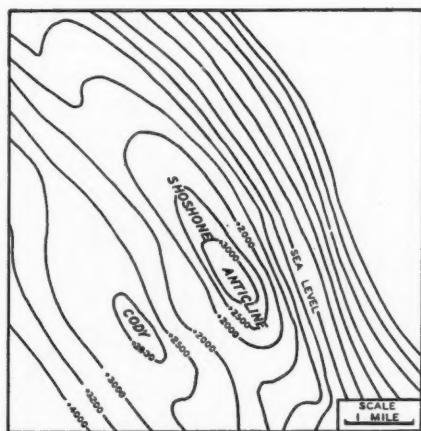


FIG. 3-A.—Structure of Shoshone and Cody anticlines, Park County, Wyoming, Contours on top of Cloverly group. Interval 500 feet.

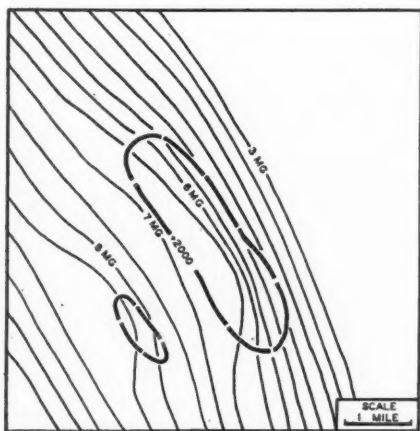


FIG. 3-B.—Gravity anomaly computed from structure outlined in Figure 3-A. Contour interval, 0.5 milligal. Heavy lines outline position of structures.

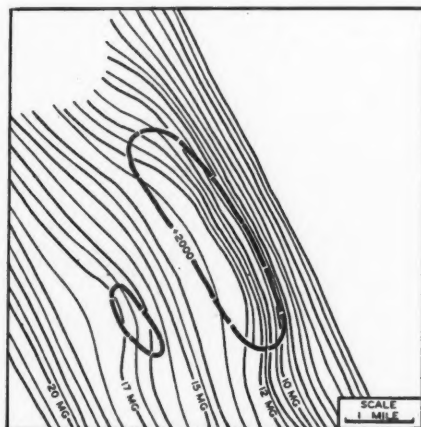


FIG. 3-C.—Gravity anomaly of Figure 3-B with regional gradient added.

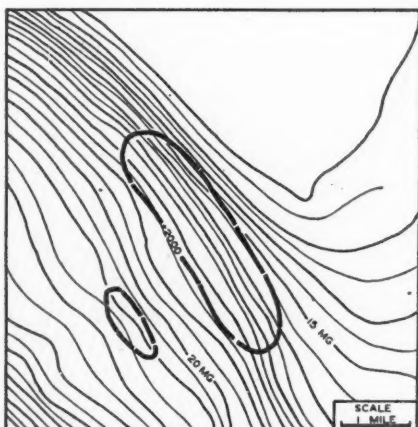


FIG. 3-D.—Observed gravity of structures outlined in Figure 3-A. Agreement between Figure 3-C and D is fair. Inaccuracy in original structural map may account for some of these differences.

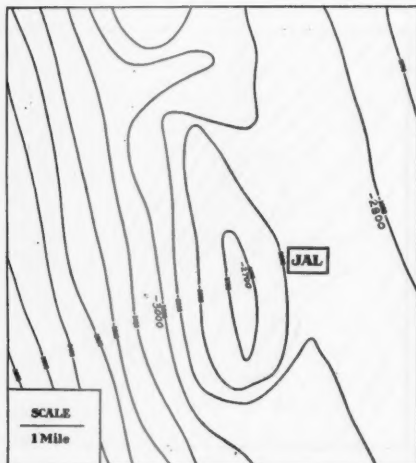


FIG. 4-A.—Structure on top of San Andres in vicinity of Jal, Lea County, New Mexico.

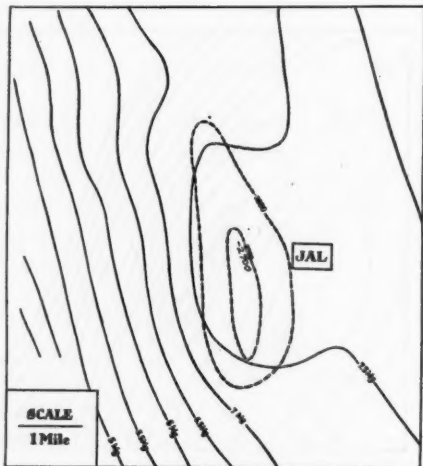


FIG. 4-B.—Gravity anomaly computed from structure of Figure 4-A. Contour interval, 0.5 milligal. Dashed lines from San Andres structure.

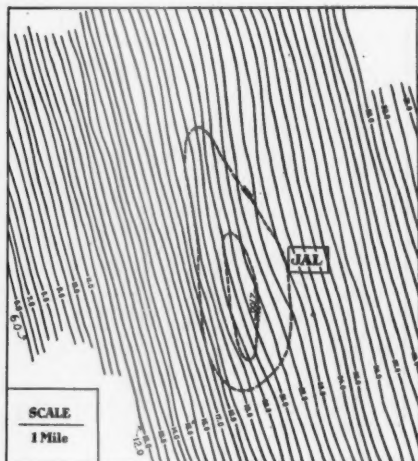


FIG. 4-C.—Gravity anomaly of Figure 4-A with regional gradient added.

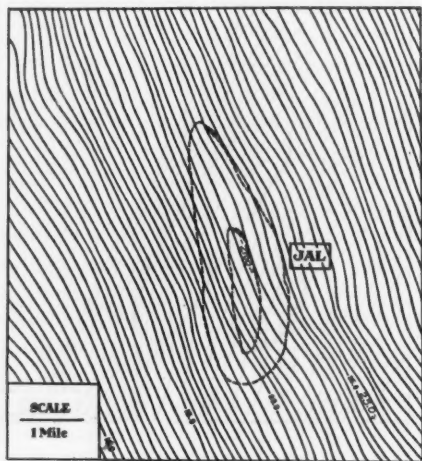


FIG. 4-D.—Observed gravity of area covered by Figure 4-A. Comparison with Figure 4-C shows similarity of anomalies immediately west of village of Jal. Need of carefully planned survey in such areas is apparent.

Two areas have been selected to illustrate the analysis outlined. The Shoshone anticline in Park County, Wyoming, having structural relief of 1,000 feet and a width of one mile, produces an anomaly of 3 milligals which is readily recognized. A marginal structure in the vicinity of Jal, Lea County, New Mexico, produces an anomaly of 0.3 milligal, which can be detected in the strong regional gradient of the area only by a well planned and carefully executed gravity survey.

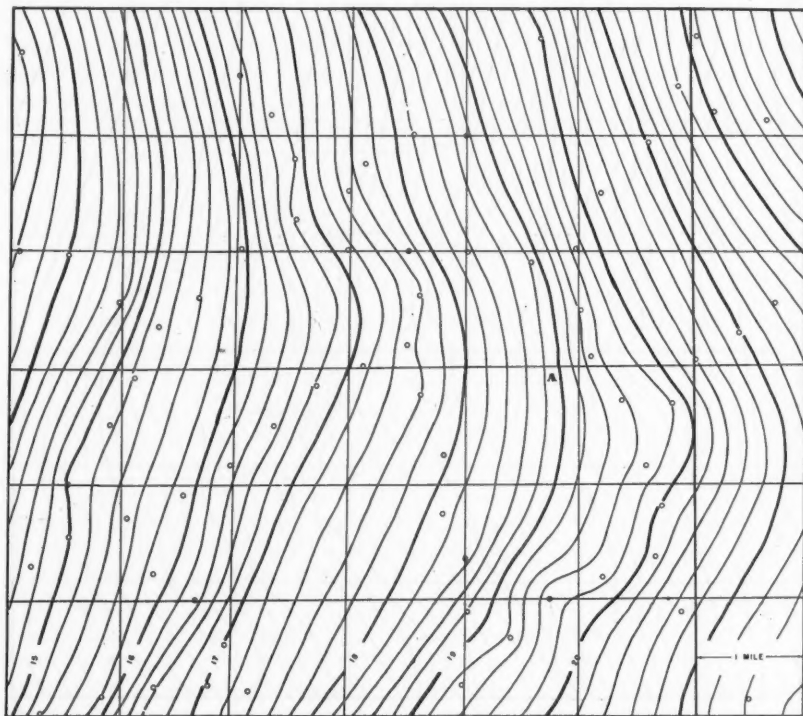


FIG. 5-A.—Gravity contours from reconnaissance survey of area in Mississippi. Salt dome is suspected in vicinity of A. Location of observations indicated by circles; contour interval, 0.2 milligal.

The Shoshone anticline is outlined in Figure 3-A, which with the densities of the formations involved permits the determination of the gravity effect at as many points as desired. Figure 3-B, resulting from such a computation, outlines the gravity effects of the structure only. To these effects has been added a regional gradient determined by study of the regional gravity map. Figure 3-C outlines this combination which can be compared with the observed gravity Figure 3-D. The two maps agree that the total anomaly is approximately 3 milligals. The

greater length of the anomaly outlined by the observed gravity is due to the inaccuracies of the original structural map and an inadequate number of stations computed.

Figure 4-A outlines a small structure on the top of the "lime" in the vicinity of Jal. The computed anomaly is mapped on Figure 4-B. In order to make a com-

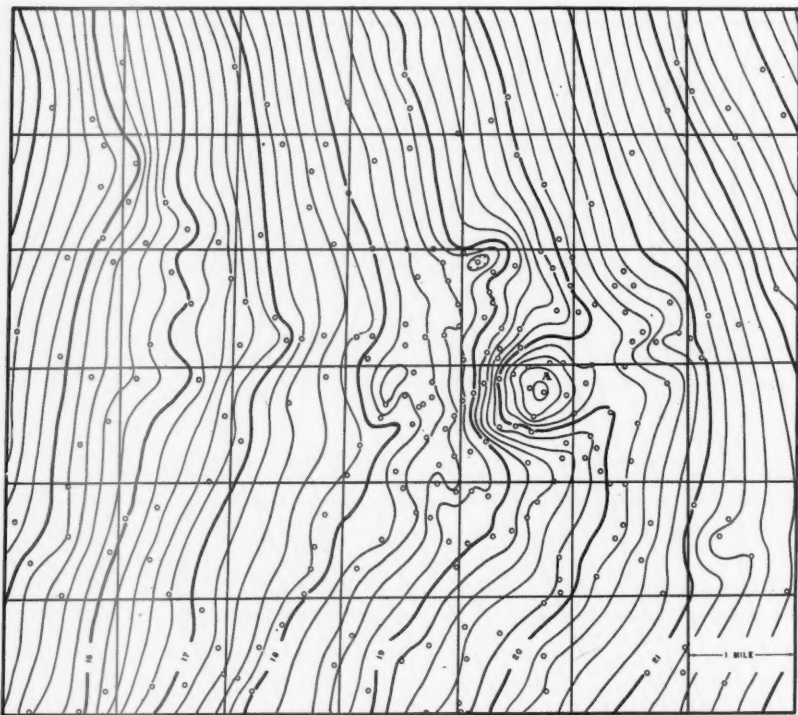


FIG. 5-B.—Gravity contours from detailed survey of area shown in Figure 5-A. Evidence of "caprock" indicates piercement salt dome confirmed by subsequent drilling. Note observations indicating presence of "cap" limited to one square mile.

parison with the observed gravity Figure 4-D, it becomes necessary to add to the local anomaly a regional gradient; this combination is shown in Figure 4-C. A comparison of Figure 4-C and Figure 4-D shows the similarity of the anomaly immediately west of Jal. A survey capable of detecting this structure need be planned with care. The anomaly noted southeast of Jal on the observed gravity map is the expression of a second structural feature in this vicinity which was not considered in the calculated gravity effects of the Jal structure.

Many surveys are inadequately controlled and thus fail where they should

succeed marvelously. One typical example is outlined (Fig. 5-A) where a casual survey suggested an anomaly which could be outlined in a general way by the original investigation. The presence of the "caprock" of a piercement salt dome was apparent only after a detailed survey (Fig. 5-B). The need of the dense pattern of observations is obvious by comparing the two maps. The observations revealing the presence of the "cap" are confined to approximately one square mile.

Few gravity surveys can be properly completed without an intimate knowledge of the geology of the surface formation. Different formations at outcrop generally require a change in density factors used and the limitations of probable error in terrane correction and other near-surface effects are better understood by field observations. Such information is obtained best in the field by a geologist who understands the geophysical problem.

A further analysis of gravity interpretation includes a brief discussion of important phases of the problem.

DIRECT INTERPRETATION OF LOCAL ANOMALIES IN TERMS OF LOCAL STRUCTURE

The ability of the gravity method to outline local structures requiring no further exploration ahead of the drilling operation is possible only in limited areas. The exploration of salt domes is, of course, an example of gravity work at its best. Other areas, however, have been explored by this method to the point requiring little, if any, additional expenditures ahead of the drilling operation.

Any structure having considerable vertical relief that brings formations with pronounced density contrasts near the surface can be outlined by the gravity method. The adequacy of such exploration is determined by the depth to the interface bounding the formations of different density, the density contrast, the vertical height of the structure and its width.

The Altus structure in Jackson County of southern Oklahoma is outlined well by this method (Figs. 6-A and B). Similar structures which can be explored with equal satisfaction, are commonly found adjacent to uplifts bringing pre-Cambrian formations or massive limestones to shallow depths. The Hobbs field, in Lea County, New Mexico, which is a large structure buried at considerable depth, was discovered by gravity and magnetic exploration. No other exploration preceded the drilling of the discovery well.

It is of interest in retrospect to note how adequately gravity exploration did outline prospective fields, although other types of exploration were subsequently employed. The Stratford dome drilled by the Indian Territory Illuminating Oil Company in the Texas Panhandle, in Sherman County, Texas, provides an example. The writer is advised that this company took the original block on the basis of magnetic exploration and completed some additional work prior to drilling the first well.

An analysis of the gravity Figure 7-A and B, and magnetic data Figure 7-C, in the vicinity of this structure is of special interest. Both types of exploration

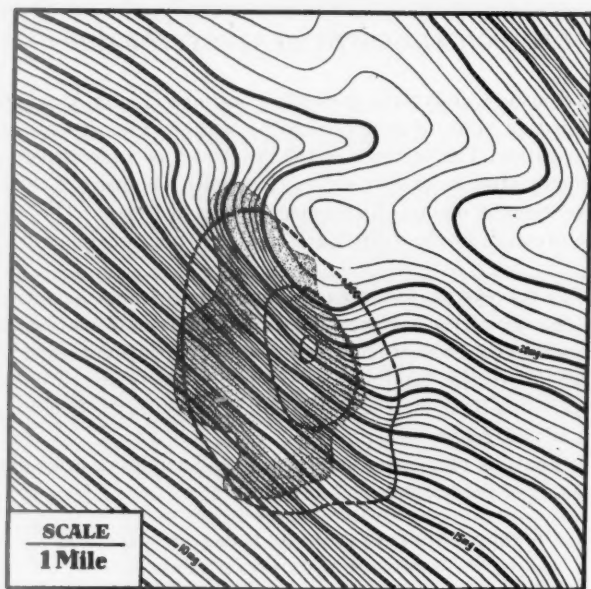


FIG. 6-A.—Gravity contours over Altus field, in Jackson County, Oklahoma. Dashed contours outline, by 100-foot intervals, structure on top of Canyon formation. Stippling encloses productive area.

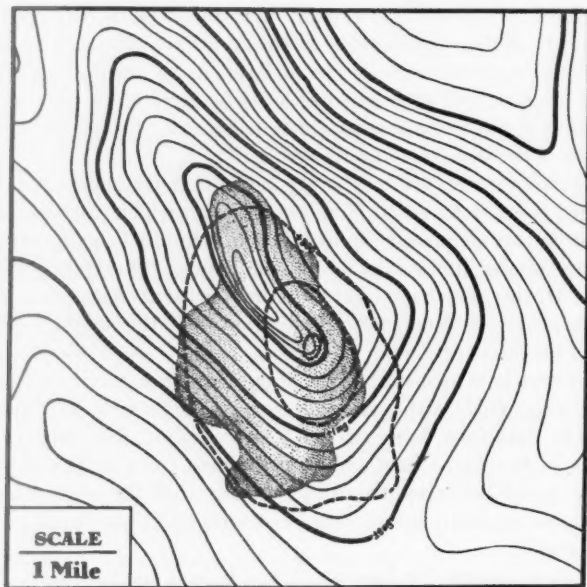


FIG. 6-B.—Residual gravity map of Altus pool shown in Figure 6-A.

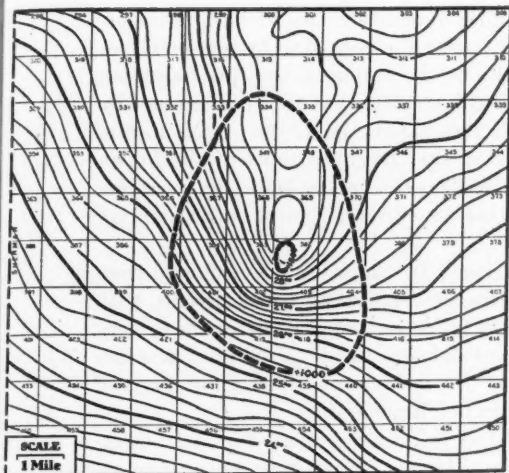


FIG. 7-A.—Gravity contours over Stafford field, in Sherman County, Texas. Dashed contour lines from structural map on top of Brown dolomite.

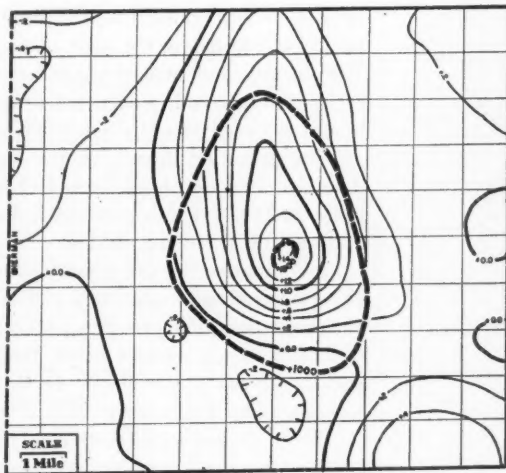


FIG. 7-B.—Residual gravity map of Stafford field shown in Figure 7-A.

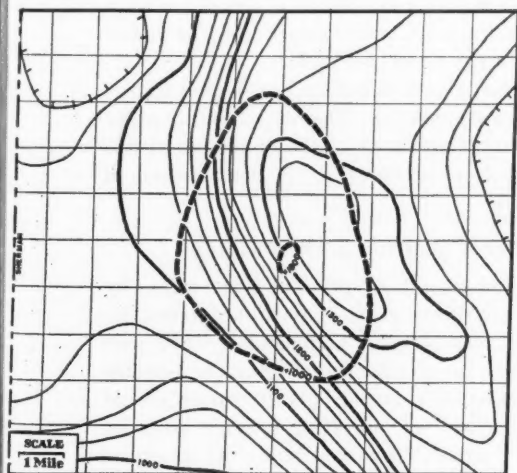


FIG. 7-C.—Magnetic contours over Stafford field shown in Figure 7-A. Contour interval, 25 gammas.

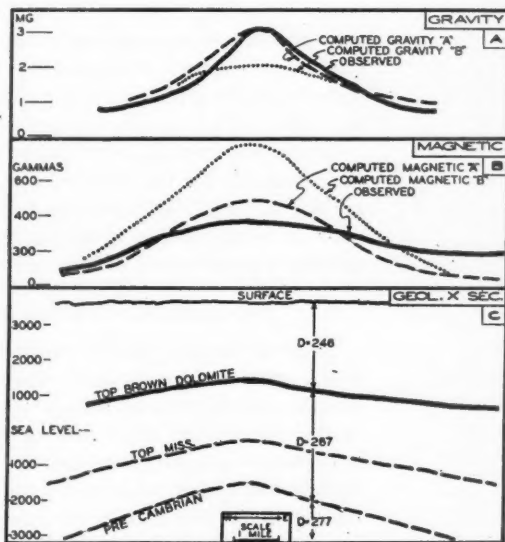


FIG. 7-D.—Geological cross section of Stafford field shown in Figure 7-A with gravity and magnetic profiles. Observed profiles (heavy lines) compare favorably with values (dashed lines) of computed gravity "A" and computed magnetic "A."

have done marvelously well in outlining the interesting area and afford opportunity to emphasize the need of understanding the geological factors involved. The density and magnetic characteristics of the sediments and pre-Cambrian rocks encountered in a deep well drilled on this structure have been determined by laboratory study and have made possible the construction of the profiles shown.

The gravity anomaly is due largely to the structural relief of the brown dolomite at a depth of 2,000 feet and its density contrast with the overlying redbeds. The magnetic anomaly is due to the structural relief of the pre-Cambrian rocks at the depth of 5,000 feet.

A comparison of the gravity profile (Fig. 7-D, Gravity "A") computed from the known density contrasts and the structures outlined by drilled wells, with the observed profile provides a satisfactory fit. Any attempt to assign the density contrasts to any surface below the brown dolomite, such as the pre-Cambrian surface, gives a profile (Fig. 7-D, Gravity "B") so far removed from the observed as to leave no doubt as to which interpretation is preferable.

Three curves have been constructed of magnetic profiles (Fig. 7-D, Magnetic): One from the observed anomaly, a second (Magnetic "A") on the assumption that the magnetic effects are confined to the pre-Cambrian rocks, and a third (Magnetic "B") computed on the assumption that the magnetic effects emanate from some formation above the pre-Cambrian in the position of the brown dolomite. A comparison of these profiles proves that the observed magnetic anomaly is due to magnetically active beds at least at the depth of the pre-Cambrian. The lack of closer coincidence of the profile of the observed anomaly with the profile representing the effect of the pre-Cambrian rocks may be due to our inability to reconstruct accurately the pre-Cambrian surface.

The evidence clearly establishes the fact that two different geological factors are responsible for the observed geophysical anomalies. The formations involved are in this particular case 3,000 feet apart. Correlative to the discussion at this point it seems possible in such a structure to predict roughly the thickness of sediments ahead of the drilling operation.

USE OF GRAVITY SURVEYS TO DIRECT ADDITIONAL EXPLORATION

Exploration by a gravity meter has low resolving power but is the means by which areas can be explored rapidly. Localizing areas of possible interest for intensive exploration by seismic or other means rightly commands a major part of the coordinated effort of this method in oil exploration. But the possible guidance of a properly processed and adequately controlled gravity survey should include much more than the simple expedient of indicating selected areas for further study. The greater value lies in the possibility of outlining the structural pattern of an unexplored area to point the way to the major features, and thus outline a long range program with emphasis on the major trends.

The analyses of a series of gravity anomalies can place them in an order of preference with intervening areas of doubtful value. A properly planned seismic

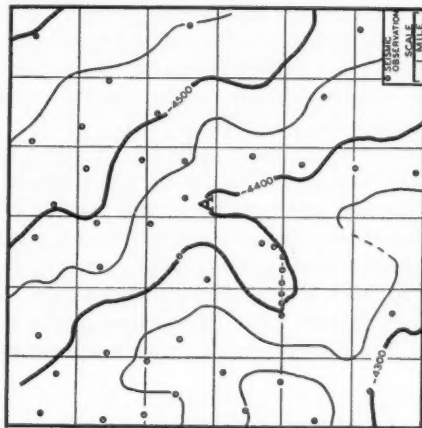


FIG. 8-A.—Contour map from seismic survey of area in Mississippi. Circles indicate points of observation. Note syncline outlined southwest of "A."

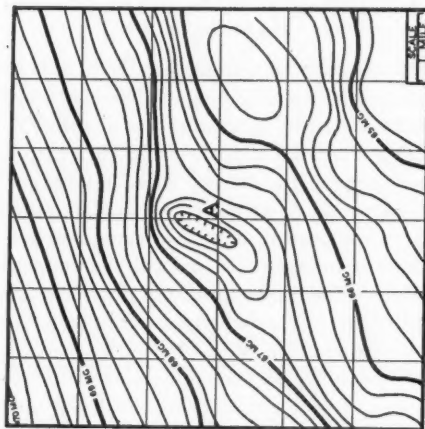


FIG. 8-B.—Gravity map of area outlined in Figure 8-A. Anomaly near point A is obvious and throws doubt upon adequacy of seismic map.

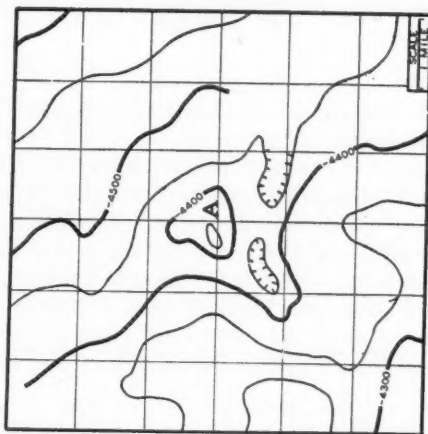


FIG. 8-C.—Final seismic map of area shown Figure 8-A after resurvey with detailed work. Although structural anomaly at A is small, it may be of interest in deeper strata.

exploration program which discovers the focal points of interest or the trends in a given area early in the investigation has many advantages and can complete the work with a minimum of time and expense.

Frequently an exploration method suitable for the average problem in a given province needs modification in selected areas to give proper emphasis to areas of deep-seated structural anomalies. Gravity surveys have pointed the way to many such areas where special effort has revealed features of interest not suspected by the original work. Figure 8-A is the result of a reconnaissance seismic survey which presumably adequately explored the area. A study of the gravity map (Fig. 8-B) prompted additional detailed work which provided a map (Fig. 8-C) prompted additional detailed work which provided a map (Fig. 8-B) unlike the original one.

ANALYSIS OF GRAVITY DATA AS AID TO QUESTIONABLE GEOLOGICAL INTERPRETATION

The analysis of gravity data can be used frequently to select the more probable of two alternate interpretations of geological information. Occasionally it can be used to prove that an existing interpretation of subsurface information can not prevail, even though it can not provide a solution which is unique.

With an accurate knowledge of the density characteristics of a sedimentary section, the anomaly which would be produced by any supposed structure can be computed. Frequently a comparison of such a computed anomaly with the observed gravity will make it necessary to discard the supposed structure as geologically impossible. Even if the method may not provide a unique interpretation, to prove the geological interpretation wrong or unlikely is to make a substantial contribution to the exploration effort.

The geologist is aided frequently by the application of the simplest concepts of the use of gravity maps. The geologist working in a basin known to have salt intrusions, such as the East Texas basin, is naturally inclined to assume that all wells not known to be structurally low are on some part of a salt uplift. With a "salt dome consciousness" the geologist outlines all his structures as salt domes and his map, wherever possible, is a series of circular uplifts tangent to each other. The use of a gravity map will immediately classify the "salt uplifts" into those which are probable and those which do not likely exist.

Faulting commonly provides the most prominent density contrasts to be found in gravity exploration. Obviously, the distribution of density contrasts due to thrust faulting is unlike that produced by normal faulting of equal vertical displacement. Occasionally these differences are such that a gravity survey will suggest the type of disturbance. The construction of a gravity profile assuming a normal fault may differ so much from one constructed on the basis of a thrust that a comparison of both profiles with the observed profile will suggest the nature of the faulting. An illustration of such a problem is presented later.

USE OF GRAVITY DATA IN STUDY OF REGIONAL GEOLOGY

Where the regional gravity features are not obscured by isostatic adjustments, or other extraneous effects, the gravity information can be used frequently to give important clues as to the regional geology. These regional features may be of the utmost importance in suggesting the major structural trends of the area or in bounding interesting provinces having a common geological history.

The possible extension and limits of the Appalachian environment are suggested by the "grain" of the regional gravity and magnetic features in Georgia and Florida. The possible limits of basins within which salt movement of con-

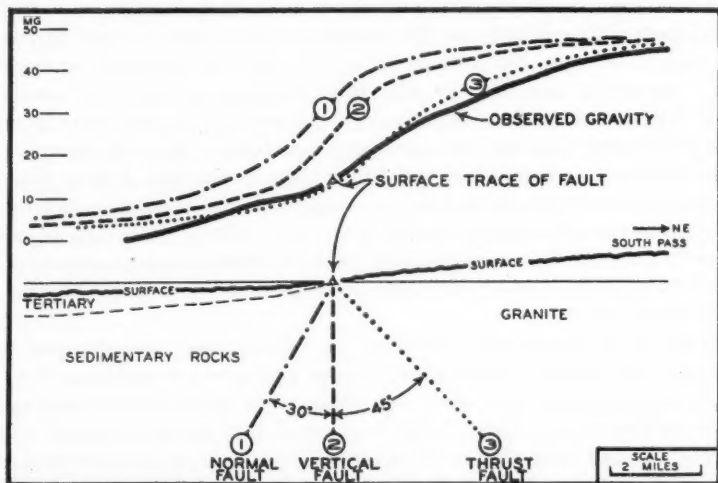


FIG. 9.—Gravity profile and cross section on southwest flank of Wind River Mountains, Sublette and Fremont counties, Wyoming. Computations of gravity are shown for (1) normal, (2) vertical, and (3) thrust faults. Comparison with observed gravity favors thrust character of faulting.

siderable proportions has taken place are suggested by certain regional gravity maps.

The faulted zone in southeastern Oklahoma, which is bounded on the west by the Choctaw fault, has a width of 50 miles. The regional gravity features point to the probability that this zone must be narrowed to 40 miles or less in the latitude of Dallas, and still less south of this point. Certain possible interpretations of the mechanics of this zone are suggested by the major gravity features but can not be discussed in this paper.

Regional gravity surveys on the southwest side of the Wind River Mountains, in Wyoming, provide evidence of the thrust character of these mountains. Figure 9 outlines an observed gravity profile across this mountain front. Three

computed profiles are shown using density contrasts which can be assigned to the beds involved with some confidence. One is computed on the assumption of a normal fault of 30° hade, a second on the assumption of a vertical fault, and a third on a basis of 45° angle thrust. A comparison of these profiles favors the thrust character of the faulting.

Problems on a smaller scale lend themselves to a similar analysis wherever beds of considerable thickness but of distinctly different density contrasts are brought in contact by faulting.

ADVANTAGES OF ACQUAINTING GEOLOGISTS WITH GEOPHYSICAL CONCEPTS

We have discussed for years the problem of how best to coordinate the work of the geologists and geophysicists. The following suggestions may not be new to many exploration units, but for some it may be a bit "left of center" or "right of center," depending upon the viewpoint. With emphasis on the better use of the low cost methods, the problem of geological interpretation becomes more involved and solutions other than the ones commonly considered suggest themselves.

The constant accumulation of quantities of geophysical data of many different sorts makes stupendous the problem of evaluating all of these data in terms of current problems which change rapidly. The many different procedures by which this can be done will not be a part of this analysis; however, one important phase of the problem follows which has tremendous possibilities of making better use of geophysical data.

Does it occur to you that the district or "grass roots" geologist may have many facts and alternate proposals explaining a given set of geological data besides the one he thinks most likely and which is the subject of his usual report with recommendations. Armed with geophysical data and with proper help in their use, he might find that his alternate solution satisfies both the geological facts as well as the geophysical data. Correlative to this thought is the possibility that the geophysical data would be the means of suggesting the alternate geological solution. Certainly, much is to be gained by a proper analysis of the geophysical data at the point of origin of new geological ideas.

The writer does not propose to make geophysicists of our "district" geologists, but he does contend that the geologist can be made to understand the basic geophysical concepts of the several geophysical methods and so better understand the limitations of each method and the data that each provides. Certainly, the possibilities of unpredicted velocity changes in the weathered layer and changes in its thickness are no more difficult to comprehend than the use of the electrical and gamma-ray logs which the geologist continually interprets. He can as readily learn to appreciate the fact that an unconformity may bring beds of unlike density in contact in sufficient quantity to become a problem for gravity exploration as he has learned to correlated insoluble residues. Faced with the necessity of assisting in the interpretation of geophysical data the geologist on the ground is in a posi-

tion to see that the best possible geological facts are forthcoming by which to process these data.

Too frequently we as geologists have dumped our geological problems into the laps of the geophysical departments and have become inert in regard to any new geological thinking. Too often we have become scouts simply reporting geological data or bookkeepers and clerks in a highly complex oil-finding organization. To what group, or individual, do we look for new ideas in our day to day problems? If we look to the geologist on the ground, the one nearest the source of geological data, he should be a member of the group which makes the final assembly of the total information. It is obvious that the geologist responsible for the current recommendations should be able to grasp geophysical concepts.

An increase in the number of geologists in the Society of Exploration Geophysicists marks a trend, however small, in the right direction. In 1940 approximately 7 per cent of our members had qualified and were on the roles of the S.E.G. In 1945 almost 9 per cent held membership in both societies. Inasmuch as the predominate expense of the oil-finding effort with which the geologist is concerned is so overwhelmingly geophysical, and will remain so in the foreseeable future, it should concern all of us to see that these percentages reach higher levels.

The most important reason the geologist, and especially the district geologist, should become acquainted with geophysical data to the point where he can use them under guidance is that such data can be the means of stimulating his imagination toward the birth of new ideas.

The optimum in geological-geophysical interpretation will be reached when one individual, or group of individuals, acts as a focus for all the geophysical data and geological information for final analyses. Obviously, the geologist on the ground who presumably is most familiar with the problems must be one of this group, and insofar as it is possible for members of this group to grasp the significance of any or all of the geophysical and geological data, in just this measure will the fullest possible use be made of the information.

Give the geologist to whom you look for new ideas freer access to geophysical information and instruct him in its interpretation. Such a scheme will stimulate his imagination and at the same time have it under control, thus providing the controlled imagination needed in our geological thinking.

GEOLOGICAL NOTES

ELMORE EMBAYMENT, GARVIN COUNTY, OKLAHOMA¹

ROBERT R. WHEELER²

Oklahoma City, Oklahoma

During the last year the discovery of several new Pennsylvanian (Deese) sand pools spotted in an arc around the basinward flank of the Pauls Valley uplift, chiefly in Garvin County, Oklahoma, makes it desirable to coin a term of differentiate the contiguous southeastern extension of the Anadarko basin. For this depressed area between the Pauls Valley and Arbuckle uplifts, the term Elmore embayment is proposed.

Structurally, the embayment developed as a complex graben comprising a series of northwest-trending fault blocks successively down-dropped southwest of the Pauls Valley uplift and northeast of the Robberson-Arbuckle uplift. Differential truncation in pre-Deese time left Caney and early Pennsylvanian rocks in the depressed area, but removed successively older rocks on the bordering positive areas.

The succeeding Deese and younger Pennsylvanian deposits lapped out on the Pauls Valley uplift and doubtless thinned over the Arbuckle high where later erosion unfortunately penetrated the Deese and older sequence to remove generally the essential evidence.

The town of Elmore, in Sec. 27, T. 2 N., R. 2 W., Garvin County, Oklahoma, is situated near the axis of the embayment which is apparently traceable south-eastward into the well known Mill Creek syncline of the Arbuckle Mountains.

¹ Manuscript received, October 16, 1946.

² Chief geologist, Eason Oil Company.

DISCUSSION

STATISTICS OF EXPLORATORY DRILLING¹

W. J. DIXON² AND R. M. SWESNIK³

Eugene, Oregon, and Oklahoma City, Oklahoma

The development of many branches of science proceeds along somewhat similar lines. It is possible that the technological science of exploratory drilling will develop in a similar manner to other sciences. The preliminary stage of exploration which is one of reporting observations upon special cases and methods, is followed by the collection of groups of data obtained in various lines of investigation. Thereupon, attempts are usually made to lay down general rules which the data may indicate and to attempt generalizations. It becomes necessary at this stage to define more precisely and concretely the vocabulary used in obtaining more nearly uniform data. As these definitions become generally accepted, the assembled data become more consistent so that summaries of data take on definite meaning. Also, when the data acquire a generally accepted meaning, they may be used more widely and they begin to have application in charting the development of the science.

At such time it becomes advantageous to apply various techniques in descriptive statistics such as graphs, charts, ratios, percentages, and mathematical approximations to the observed data. For as the data gathered become extensive, it is necessary to use methods of organization to bring the facts within the compass of our understanding, methods of analysis to make the essential relations appear out of the mass of detail in which they are hidden, and methods of classification and description to facilitate the presentation of the data for the study and consideration of other persons. When the data are organized in this manner it becomes possible to make predictions for the future, for, in order to plot the future development in a science, it is necessary to make a careful study of the rate and direction of the development in the past. Further, such investigations often propose new questions to be answered.

These various processes are collectively known as the statistical method. Some of these processes are simple and others elaborate, involving complicated mathematical methods and conceptions. The development and application of these methods constitute a distinct science. The simple processes have a wide general use while the more elaborate processes have specific applications in special cases.

The petroleum industry appears to be passing through these same phases. It now has a well defined vocabulary with respect to exploratory drilling. This was greatly facilitated in 1944 by F. H. Lahee,⁴ who has taken an active interest in compiling data on exploratory drilling,⁵ and was necessarily led to a standardization and formulation of precise definitions.

¹ Manuscript received, October 24, 1946.

² Professor of mathematics, University of Oregon.

³ Geologist, Anderson-Prichard Oil Corporation.

⁴ Frederic H. Lahee, "Classification of Exploratory Drilling and Statistics for 1943," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 28, No. 6 (June, 1944), pp. 701-21.

⁵ *Idem*, "Wildcat Drilling in 1935 and 1936," *ibid.*, Vol. 21, No. 8 (August, 1937), pp. 1079-82.

———, "Wildcat Drilling in 1937," *ibid.*, Vol. 22, No. 6 (June, 1938), pp. 645-48.

———, "Further Data on Wildcat Drilling in 1937," *ibid.*, Vol. 22, No. 9 (September, 1938),

pp. 1231-35.

———, "Wildcat Drilling in 1938," *ibid.*, Vol. 23, No. 6 (June, 1939), pp. 789-99.

———, "Wildcat Drilling in 1939," *ibid.*, Vol. 24, No. 6 (June, 1940), pp. 953-58.

———, "Wildcat Drilling in 1940," *ibid.*, Vol. 25, No. 6 (June, 1941), pp. 997-1003.

As an example of the application of descriptive statistics to such data, a few graphs and computations are presented, based on Lahee's compilation of data in the June, 1946, issue of this *Bulletin*.⁶ No attempt is made to make a complete analysis of the type possible

CHART I

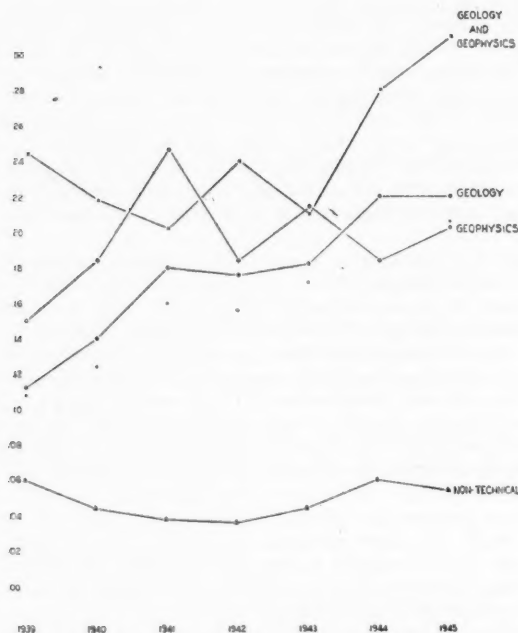


CHART I

at this time. Also, many very interesting statistical studies await the time when data have been accumulated for a greater number of years.

Lahee⁷ expressed much more confidence in data for the years following 1938; there-

—, "Wildcat Drilling in 1941, with Comments on Discovery Rate," *ibid.*, Vol. 26, No. 6 (June, 1942), pp. 969-82.

—, "Wildcat Drilling in 1942," *ibid.*, Vol. 27, No. 6 (June, 1943), pp. 715-20.

—, "Classification of Exploratory Drilling and Statistics for 1943," *ibid.*, Vol. 28, No. 6 (June, 1944), pp. 701-21.

—, "Exploratory Drilling in 1944," *ibid.*, Vol. 29, No. 6 (June, 1945), pp. 629-45.

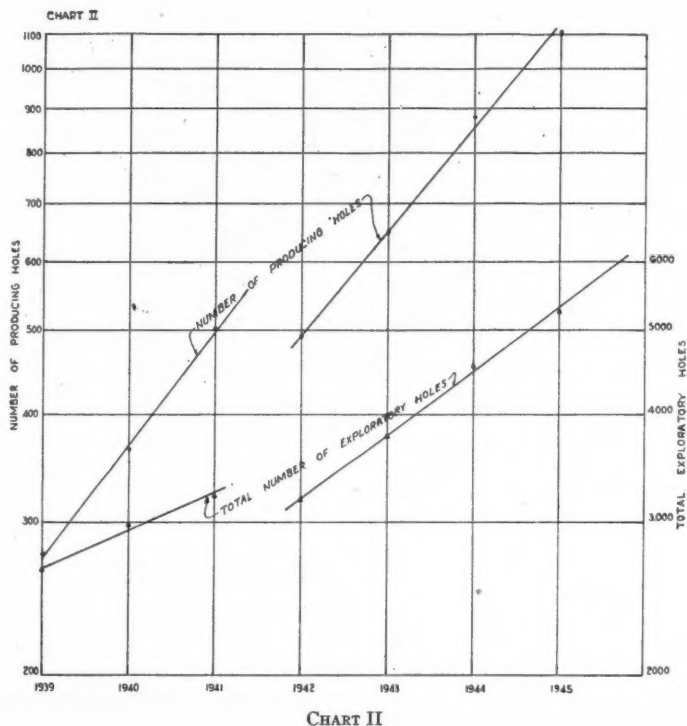
—, "Review of Exploratory Drilling Statistics, 1938-1944," *ibid.*, Vol. 29, No. 11 (November, 1945), pp. 1581-92.

⁶ —, "Exploratory Drilling in 1945," *ibid.*, Vol. 30, No. 6 (June, 1946), pp. 813-28.

⁷ *Ibid.*

fore, data from earlier years are not considered here. The years 1939 to 1945 give us, statistically speaking, a sample size of seven (based on years), which is actually very small for a time-series analysis; therefore, any predictions made are not as precise as they would be with a larger sample size. Nevertheless, several interesting inferences are possible.

In addition to the presentation of the data given by Lahee, mainly in tabular form, a presentation of part of the data in graphical form should serve to show more clearly some of the fundamental trends. Also, one may more readily determine the basic fundamental mathematical laws these curves follow. Of course, the graphical presentation has the dis-



advantage of requiring more space, but if such data are of interest, the extra space required may be worthwhile.

Of primary interest to all petroleum geologists are these questions: (1) How effective are our methods? (2) How do our methods compare with those of the geophysicists and can we be of aid to them? Further, (3) how much more effective are our methods than sundry non-technical methods? To answer these questions let us critically examine Chart I. This chart was prepared from Table VII, page 825 of Lahee's article.⁸ The points plotted were obtained from his data by finding the ratio of producers and dividing this to the

⁸ *Ibid.*

total number of producers and dry holes in each category for every year. If this quotient be defined performance, we can then compare methods in terms of performance.

First, let us examine the performance of the geologists. It is readily seen that since 1939 they have steadily improved each year with the exception of 1941 to 1943, when their performance remained essentially constant. Perhaps this may be attributed to the addi-

CHART III

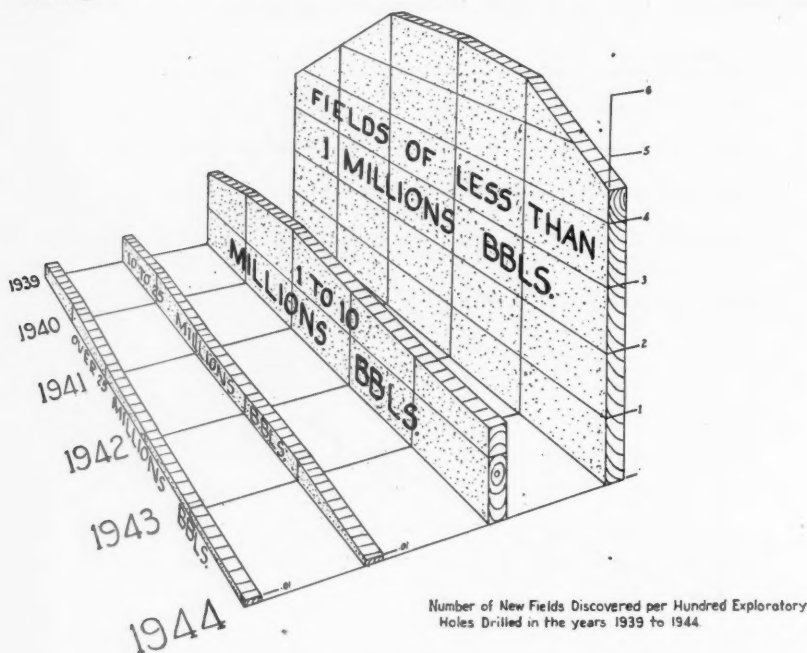


CHART III

tional load they were obliged to carry due to the war, with the resultant lack of research. However, after the stabilization period they again improved.

The geophysicists have had a rather fluctuating performance, dropping off to a performance record of 0.18 in 1944. This fluctuation again shows the results of the war. For the years 1939 to 1943, the geologists were between 0.04 and 0.06 unit behind the geophysicists. From a comparison of the two methods, it seems as though the geophysicists' performance is erratic from year to year and is not improving, whereas the geologists' performance is steadily improving and is now superior to the purely geophysical methods.

Working together the geologists and geophysicists have consistently had an appreciable edge on any other method. Only in 1941 was their combined performance less than by any other methods. In 1944 and 1945 their high performance may be due to better geologic technique, for in those years the geologists alone showed a much better performance than the geophysicists.

Sundry non-technical⁹ methods have had less and less success until 1944, when their performance increased to 0.08, the highest for the period 1938-1945. A likely explanation might be that what has been considered non-technical in 1944 might have been considered technical 7 or 8 years previous, due to the rapid advances made in the technique of exploratory methods. However, their performance did not further increase in 1945.

The total of all these methods indicated by unjoined dots, shows steady improvement. It may be predicted by extrapolation of this trend that the total performance for 1946 of all methods will be approximately 0.23.

Chart II shows the number of producers and total number of exploratory holes drilled for the several years considered. It appears that the outbreak of war affected the number of wells drilled and held this number essentially constant for 12-14 months. The points have been plotted with the coordinates adjusted (semi-logarithmic coordinates) so that exponential curves will appear as straight lines. The fact that these points lie in essentially a straight line here indicates that the numbers are increasing exponentially. There appears to be an essential difference in the drilling operations before 1941 and after 1942. Exponential curves fitted to the data from 1942 to 1945, inclusive of the general form $N = A \cdot B^t$ where t represents time. 1942 is $t = -4$, 1943 is $t = -3$, 1944 is $t = -2$, 1945 is $t = -1$, and 1946 is $t = 0$. For producers the curve is $1,480 (1.32)^t$; for total number of holes is $6,320 (1.20)^t$. The ratio of these two quantities for 1946, which we have defined as performance, gives 0.234. The ratio of the two quantities is 0.5 for 1952. It is of interest that a performance of 0.5 is predicted for 1952. This means that half of all exploratory wells will be successful in 1951 if present trends are followed. This may be attributed to several possible causes, the most plausible being that now with the mass of subsurface data both geophysical and geological work is improving, and also the fact that more wells are being drilled on geological and geophysical data and less on sundry non-technical methods. Any basic change in methods which alters the trend or further information on the type of curves to be fitted to the data may, of course, alter the picture. It must be borne in mind, however, while performance in 1952 may be 0.5, that the size of fields is apt to be much smaller as indicated by the present trends.

Chart III shows the number of new fields discovered per 100 exploratory holes drilled. The data are divided into groups according to the probable size of the field. In general, the picture indicates that over a period of years the average size of field being discovered is decreasing. In the last 4 years, however, the number of fields of more than 10 million barrels productive capacity per 100 exploratory holes has continued to decrease and there has been no increase, in fact, a slight decrease, in the number of the smaller fields discovered per 100 exploratory holes. The number of fields of less than 1 million barrels has dropped sharply in 1944.

It is pointed out, in conclusion, that with the ever accumulating data on the success of various exploration techniques, conclusions of great economic significance not previously obtainable can be drawn by the application of proper statistical methods.

⁹ Sundry non-technical methods as considered by Lahee are "creekology," "hunch," "doodlebug," promotion, lease obligation, reported showing of oil or gas in holes previously drilled, *et cetera*. Vol. 28, No. 6 (June, 1944), p. 713.

TECTONIC FRAMEWORK OF NORTHWESTERN SOUTH AMERICA¹F. E. VON ESTORFF²

New York, N. Y.

In his discussion of the writer's recent paper "Tectonic Framework of Northwestern South America"³ Victor Oppenheim⁴ has offered some criticism which indicates the need for clarification of the points raised.

The writer fully agrees with Victor Oppenheim that "the forces that acted upon and shaped this part of South America are manifold and complex." However, as pointed out by the writer in his introduction the purpose of the paper under discussion was "to analyze the rigid framework of the basement complex." In order to accomplish this an attempt was made to eliminate the confusing effect of minor structural elements so as to distinguish the major and persistent elements of the framework. Many and varying less persistent trends locally seem to be very significant. On studying regional structural relations, however, it can be observed that the less persistent trends are most common at the junction of the major northeast and northwest trends and appear to be the result of the composite effect of the two major elements. This applies for instance to eastern Venezuela and may also apply to Santa Marta.

As to a north-south structural trend of the Andean Ranges between 18° and 50° Lat. S., both physiography and structure suggest that alternating northeast and northwest elements are responsible for the apparent north-south trend. The two elements are even more definitely expressed in the structural pattern of adjacent Argentina.

The division of areas into "positive" and "negative" is based not "on present topographic forms related to an arbitrary 6,500-foot level" but on areal geology reflecting structure. The areas above 6,500 feet were merely added to show the relation between high mountains and outcrops of basement or igneous rocks which offer the principal evidence of the rigid framework. The old positive areas actually reflect barriers between sedimentary basins whereas the younger positive areas indicate more recent uplift across former basins of deposition. For detailed geologic evidence of trends the reader is referred to the "Geologic Map of South America"⁵ and the "Source of Geologic Data" listed on this map.

The difficulty of separating relatively young volcanics from pre-Paleozoic igneous rocks has been fully appreciated by the writer as stated on page 583.⁶ "Although it would be preferable to separate the younger igneous intrusives from the area of rigid rocks representing the older framework not all can be separated due to our present limited knowledge." However, the orientation of these younger igneous rocks along the same major trends strengthens rather than weakens the theory as set forth in the paper under discussion.

Evidence of structural trends other than northeast-southwest in southern Brazil and Uruguay does not necessarily contradict the physiographic evidence of a major northeast trend along the coast, a trend which is confirmed and even better expressed in the form lines of the continental shelf and slope.⁷ The shelf contours off the coast of Brazil inci-

¹ Manuscript received, October 19, 1946.

² Socony-Vacuum Oil Company.

³ *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 30, No. 4 (April, 1946), pp. 581-90.

⁴ *Ibid.*, Vol. 30, No. 9 (September, 1946), pp. 1589-90.

⁵ *Geologic Map of South America*. Published by the Geological Society of America (1945). Scale, 1:5,000,000.

⁶ *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 30, No. 4 (April, 1946), p. 583.

⁷ *Geologic Map of South America*.

dentially offer the most prominent physiographic evidence of a northwest cross-trend between Lat. 21° S. and Long. 33° - 40° W. Physiographic or geologic evidence of a dominant northeast or northwest element naturally does not exclude the possibility that there were older trends which are less discernible to-day and on which the northeast and northwest trends have been superimposed.

The writer wishes to express his appreciation for the interest in this problem by Victor Oppenheim whose geologic work in South America has greatly added to our knowledge of the geology of this continent. It is hoped that the present discussion will clarify the points in question and contribute to a better understanding of regional tectonics.

DISTINGUISHED LECTURE TOUR

H. N. Fisk, professor of geology at Louisiana State University, Baton Rouge, Louisiana, spoke before the following groups in December. His subject was "Geology of the Lower Mississippi Valley." Fisk's duties as a consultant for the Mississippi River Commission and his extensive studies of the geology of the Gulf Coast make him one of the foremost authorities on the Lower Mississippi Valley area. He points out, geologically speaking, that the Mississippi River is one of the youngest major streams in the world inasmuch as it had its origin in early glacial time.

- December 2—Mississippi Geological Society, Jackson
3—Southeastern Geological Society, Tallahassee, Florida
5—Indiana-Kentucky Geological Society, Evansville, Indiana
6—Geological Club, University of Wisconsin, Madison
9—University of Iowa, Iowa City
10—Illinois Geological Survey, Urbana
12—Tulsa Geological Society, Tulsa, Oklahoma
13—Shawnee Geological Society, Shawnee, Oklahoma
16—North Texas Geological Society, Wichita Falls
17—East Texas Geological Society, Tyler
18—Houston Geological Society, Houston, Texas
19—South Texas Section, A.A.P.G., San Antonio
20—Corpus Christi Geological Society, Corpus Christi, Texas
23—South Louisiana Geological Society, Lafayette

RESEARCH

FINAL REPORTS ON A RECONNAISSANCE SURVEY OF RESEARCH NEEDS IN PETROLEUM GEOLOGY

BY
THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
RESEARCH COMMITTEE

1945-1946

FOREWORD

The Research Committee of 1945-1946 completed a reconnaissance survey of research needs in petroleum geology and recommended nine major projects as needing formulation. These projects have been approved by the Executive Committee and have been assigned to project chairmen. It is expected that formulation of all nine will be completed this year.

There was no thought of making a complete survey but only of completing a reconnaissance. It is not surprising, therefore, that two additional projects have already been added to the list. Still others will probably be developed during the formulation of the ones already adopted, and it seems reasonable to suggest that this initial group may gather momentum, under the impetus of interest and urgency.

The following report by Philip B. King, chairman of the Subcommittee on Tectonics, is the first of three that will be published in the Research Department in the *Bulletin*. The other two, giving the results of the survey on Stratigraphy and Sedimentation, and Reservoir Fluids, will appear early in 1947.

These reports speak for themselves. It is a pleasure and a privilege, once again, to thank their authors and the other members and consultants of the Research Committee who aided in this work.

SHEPARD W. LOWMAN

REPORT OF SUB-COMMITTEE ON TECTONICS¹

PHILIP B. KING,² CHAIRMAN
Washington, D. C.

TABLE OF CONTENTS

Introduction	2043
Scope of subject	2043
Research in tectonics	2044
Work of the sub-committee	2044
Recommendations	2045
Local projects	2046
1. Areal geology of United States	2046
2. Structure symbols on maps	2047
3. Detailed study of salt domes	2047
4. Detailed studies of other oil-bearing structures	2048

¹ Published by permission of the director, Geological Survey, United States Department of the Interior.

² United States Geological Survey.

Regional projects.....	2048
5. Geologic maps of states.....	2049
6. Geologic structure maps of states.....	2049
7. Comprehensive studies of regions.....	2050
8. Work of Fuels Section of United States Geological Survey.....	2052
9. Work of Yellowstone-Bighorn Research Association.....	2053
10. Studies of fracture systems.....	2053
Interregional projects.....	2054
11. Revision of tectonic map of United States.....	2054
12. Related projects.....	2055
13. Contour map of United States on top of basement rocks.....	2056
14. Distribution of North American geosynclines in time and space.....	2057
Geophysical projects.....	2057
15. Gravimetric map of United States.....	2057
16. Magnetic map of United States.....	2058
17. Tectonic data from level lines and triangulation nets.....	2058
18. Oceanographic studies.....	2058
General and theoretical projects.....	2058
General nature of the problem.....	2059
19. Field projects.....	2059
20. Laboratory experiments.....	2060
Accessory items.....	2062
21. Definitions.....	2062
22. Base maps.....	2063
23. Bibliographies and abstracts.....	2063

INTRODUCTION

This report summarizes the status of research in tectonics, and especially of research which relates to petroleum exploration. It also summarizes the work and the recommendations of the sub-committee on tectonics of the research committee of the American Association of Petroleum Geologists between September, 1945, and April, 1946.

SCOPE OF SUBJECT

What is tectonics? The word is derived from the same root as "architecture" and may be thought of as "the architecture of the earth." Webster's dictionary defines it as "that branch of geology concerned with rock structures, especially folding and faulting, resulting from deformation of the earth's crust." As such, the term is more or less synonymous with "structural geology" as this is used in geologic reports, text books, and college courses.

The field of tectonics is broad and rather indefinite, with many overlaps into other branches of the earth sciences. A worker in tectonics must consider not only the rock structure itself, but also stratigraphy, geologic history, geomorphology, and geophysics. Conversely, much work done in stratigraphy, historical geology, geomorphology, and geophysics has tectonic implications. Much work in tectonics is done along with or as a by-product of other work. Every geologist who prepares a geologic map or well-log cross section must consider geologic structure, but the amount and significance of the structure are variable.

The present report is limited to that part of tectonics which relates to petroleum geology and petroleum exploration. Considered narrowly, this would limit the scope of the report to only part of the field, as petroleum is not likely to be found in igneous and metamorphic rocks except at or near their contact with the sedimentaries. In fact, the projects discussed which have most immediate practical value are restricted in subject matter. Nevertheless, petroleum geology overlaps into so many diverse fields that effective long-term progress would seem to be best served by taking a broader view, even though the apparent relation of some of the subject matter to petroleum geology may seem remote.

RESEARCH IN TECTONICS

Research in tectonics may be grouped into three categories: (a) fact gathering, (b) assemblage and synthesis of facts, and (c) research leading to an interpretation of facts. The relative merits of the three types have been much debated. The extreme view has been expressed that the first two categories are not research at all, or at least not "fundamental" research of the sort that should interest us. Also, that work of this sort would merely duplicate that done by oil companies as a part of their routine commercial operations. A similarly extreme view has been expressed that the third type is too far removed from the present needs of petroleum exploration to be of practical value. Probably neither of these extremes is justified.

In this connection, two more moderate expressions of opinion deserve quotation. Reed and Hollister,³ in their discussion of the tectonics of southern California, point out the dangers of making purely speculative explanations of the mechanics of structural features, when the features themselves and their geologic history are poorly known or poorly synthesized.

Structural geologists . . . will wonder . . . where the writers propose to discuss the dynamic problems that bulk so large in most treatises similar to the present one. What is the nature of the forces that from time to time have deformed the crust of coastal California, and what is their origin? Were the mountains warped up, thrust up, or elevated in some other way? To all such questions the writers must answer that they do not know. They must state further that in spite of their best efforts they do not yet know as definitely as they would like just what structural events happened from time to time and from place to place in the California province; and they may as well confess that they doubt the advisability of creating mechanical hypotheses, except for mnemonic purposes, until the succession of events to be explained has been well worked out.

M. K. Hubbert points out the need for actual research (as opposed to speculation and deduction) on the origin of structural features, making use of mechanical and other principles that have been developed in the physical sciences:

For many years geologists have been making and recording very good observations on geologic structures. They have also frequently sought to give some kind of a mechanical explanation of the manner in which these structures have originated. Unfortunately these attempts have most often been very naive and quite inadequate for the fulfillment of the purpose for which they have been intended. My feeling is that an empirical knowledge of any subject, although perhaps necessary as a first step, can hardly be said to be more than half the required development of that subject. In structural geology, our knowledge has barely gone beyond this empirical stage. Consequently, to my way of thinking, the most important research that remains to be done in the field of tectonics is to bring our understanding of the physics of such phenomena to where it is comparable to our empirical knowledge of the subject. This is partly a problem in complex mechanics—the mechanics of deformable bodies—partly a problem of gravitational potential, and partly a problem in thermodynamics.

WORK OF THE SUB-COMMITTEE⁴

The sub-committee on tectonics of the research committee of the Association was organized in September, 1945, and served through April, 1946. It included the following members of the main research committee: A. H. Bell, P. B. King, R. A. Liddle, and W. T. Thom, Jr., with King as chairman of the sub-committee. In addition, the following other geologists acted as consultants: W. H. Bucher, Ernst Cloos, James Gilly, M. K. Hubbert, C. R. Longwell, and C. W. Tomlinson.

From September to January a survey was made of the field of tectonics and its research possibilities. A preliminary outline of the subject matter was prepared and circulated, and

³ R. D. Reed and J. S. Hollister, "Structural Evolution of Southern California," *Bull. Assoc. Petrol. Geol.*, Vol. 20 (1936), p. 1685.

⁴ For a general summary of the work of the research committee, see S. W. Lowman, chairman, "Report of the Research Committee," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 30 (1946), pp. 787-89.

written comments and contributions were solicited from committee members, consultants, and geologists in general. A meeting of the sub-committee was held toward the end of December at the Pittsburgh convention of the Geological Society of America, at which many issues were clarified.

The fruits of this work were embodied in a preliminary report of the sub-committee that was submitted in mid-January. This was issued as a chapter in the general progress report of the research committee.⁵

A second meeting of the sub-committee on tectonics was held in early April at the Chicago convention of the American Association of Petroleum Geologists. Here, the main objective was to summarize the survey that had already been made, and to crystallize the results into concrete recommendations. These are given under the next heading.

The present report includes the survey of tectonics and the recommendations resulting from it. It was written by the chairman (P. B. King) who has edited and coordinated the contributions of the other geologists, summarized the results of discussions at meetings of the sub-committee, and added appropriate published material. The report contains much of the material presented in the earlier preliminary report, but with some additions and deletions.

RECOMMENDATIONS

In reviewing the subjects and projects listed in its preliminary report, the sub-committee found that they could appropriately be grouped into four classes:

1. *Recommended.*—Projects favored by the sub-committee and deserving the support of the Association, in order that they may be either initiated or completed.

2. *Commended.*—Projects favored by the sub-committee, but already being successfully carried out by other research groups.

3. *Formulation needed.*—Projects favored by the sub-committee, but on which information is lacking as to details of objectives, personnel, funds required, etc. If detailed formulation can be made, the sub-committee would wish to reclassify them as recommended projects at a future time.

4. *No action.*—Subjects or projects that are either indefinite in scope, out of the main line of interest of petroleum geology, or of more direct concern to another sub-committee (stratigraphy, geophysics, *et cetera*.) None of these projects is disapproved, and some might materialize into recommended projects at a future time.

In this classification, relatively few projects can be placed in the first, or immediate class at the present time, and most of these are along the lines of fact-gathering and synthesis, rather than the more fundamental interpretative research. This is perhaps a natural result of the particular time at which the report is written. Possibly as post-war conditions become stabilized more detailed formulation of interpretative projects will become possible.

The sub-committee's grouping of subjects and projects in the first three categories is as follows. Numbers serve as cross-reference to descriptions in the text that follows.

1. *Recommended*

- a. Areal geology of United States, on 1:62,500 or similar scales (1)
- b. Geologic maps of states, on 1:500,000 or similar scales (5)
- c. Revision of tectonic map of United States (11)

2. *Commended*

- a. Work of Fuels Section of United States Geological Survey (8)
- b. Work of Yellowstone-Bighorn Research Association (9)
- c. Geologic structure maps of states (6)
- d. Contour map of United States on top of basement rocks (13)

⁵ S. W. Lowman, chairman, *Progress Reports of the Research Committee* (mimeographed book), Amer. Assoc. Petrol. Geol. (January 15, 1946).

3. *Formulation needed*

- a. Detailed study of salt domes (3)
- b. Studies of fracture systems (10)
- c. Laboratory experiments (20)

LOCAL PROJECTS

Under the heading of local projects are grouped those which deal with small areas, such as oil fields and groups of oil fields, quadrangles, and significant minor structural units. Most of the proposals represent basic fact-gathering, the first type of research listed above, to be carried out by the conventional methods of field mapping and detailed subsurface study. The immediate effects of such work are small and practical; the development of individual oil fields or extension of fields, or the analysis of some structural feature of second or third order.

However, work of this sort already constitutes much of the day to day routine of the oil companies, so that any projects suggested should have larger or more philosophical implications. Areal mapping is thus not considered significant unless the blocks of quadrangles are large enough to contribute to a regional picture. Studies of oil fields and local structural features are not proposed unless they contribute to a regional problem or are representative of a general structural type.

1. *Areal geology of United States.*—The sub-committee on tectonics recommends the completion of the geologic mapping of the United States on a large scale (1:62,500, 1 inch to the mile, or some comparable scale) and its publication in a uniform, readily accessible series of sheets.

This project is not strictly tectonic, but falls more in the class of general geology. However, it will serve as the fundamental basis for a large amount of research in geology, be it in tectonics, stratigraphy, geophysics, or petroleum geology. Blocks of contiguous quadrangles would illustrate the character of individual regions, and the maps could be used as a starting point for technical and specialized investigations.

Recommendations of petroleum geologists as to areas that should be given priority would perhaps be desirable—such areas being those that would aid in oil finding, or aid tectonic and other research of interest to petroleum geologists. However, A. I. Levorsen expresses the opinion that petroleum geologists would be interested in the mapping of any areas of sedimentary rocks.

Relatively minor considerations, but of interest to petroleum geologists, are the facts that oil fields continue to be discovered for which there are good surface indications, and that such an extensive program might furnish training in field work for prospective petroleum geologists, a training whose need has been stressed by F. H. Lahee.

Considerably less than half the country is now adequately mapped by modern standards, and many geologic notions that we consider well established actually rest on an insecure basis of inadequate mapping. Existing mapping is, moreover, difficult to locate, because it appears piecemeal in a host of publications: federal and state bulletins, society organs, technical journals, or even in guidebooks or other ephemeral publications. The maps generally cover irregular areas, some overlapping on others, some failing to meet or match; they are on all conceivable scales, and vary widely in form of presentation, symbols used, *et cetera*.

A start at a uniform series of large-scale geologic maps was made by the United States Geological Survey in its folio series, following out the authorization of the Survey to prepare a geologic map of the United States. This series has been virtually abandoned for many years, although the present administration of the Survey is considering reviving it in modified form. Many of the older folios are now obsolete and would require redoing to bring them up to modern standards of representation, interpretation, and scale. Nevertheless, the plan behind the old folio series deserves reconsideration now—uniform set of

sheets in quadrangle form, constituting a single and thus readily accessible series.

Areal geologic mapping of this type could probably best be carried out by the United States Geological Survey, but with the cooperation of the State Surveys. Possibly university work (faculty research and thesis problems) could in some manner be integrated with the program. Oil companies at present do comparatively little surface mapping, and then only of selected areas of immediate interest. The work would therefore not duplicate oil company work and yet would furnish valuable background material for petroleum exploration.

In connection with the confusing status of existing mapping, attention should be called to a catalogue of all areal geologic maps in the United States which is now nearing completion, the work being done under the direction of Miss Leona Boardman for the United States Geological Survey. Areas covered by published maps are outlined on a set of state maps, and cross-referenced by number to a bibliography. Plans for publication have not yet been made, but such publication would seem to be of great aid to geologists of the United States.

2. *Structure symbols on maps.*—In connection with the preparation and publication of areal geologic maps, it is of interest to consider Ernst Cloos' plea for more adequate use of structure symbols on maps:

I would like to see this committee take a strong stand . . . on the use of structure symbols on geologic maps. Some time ago I sent a report to the Geological Society of America that structure symbols are lacking in 25% of all the U. S. Geological Survey maps, where the Alaskan Branch is the worst offender, and that even the Geological Society does not force the author to put them on. . . . I think the time has come that structure symbols be put on maps as they have done in England, Scotland, Sweden, Norway, etc. since 1868. . . . I think that this tectonic committee should push that point vigorously, and perhaps . . . the Geological Survey would progress another little step and with it all the State Surveys too.

There is some question as to how far the geologist should go in observing and recording structural observations, especially in the course of an ordinary areal survey. Some features have only specialized value and could best be studied during tectonic research that would follow the general mapping of the area. However, every good field man observes and records certain features during the course of his work and perhaps these could be set up as minimum standards for an areal geologic map: dips and strikes of bedding, overturning of beds (where present), dips and strikes of cleavage, upthrown sides of faults, dips of faults (where observed), anticlinal and synclinal axes, and pitch of axes. Even these data may crowd the map unduly, and in this case might be shown on a separate map or oversheet, along with additional features such as lineation, flow lines, distribution of fractures, and structure contours, for which the author of the map might have obtained data.

These remarks apply particularly to regions of considerable deformation. Many such regions are outside the field of interest of petroleum geologists, but they are not lacking in oil-bearing regions. Many petroleum geologists with whom the writer has discussed the matter have expressed the opinion that representation of structure in oil-bearing regions is adequate, and point to the oil and gas maps of the Fuels Section of the Geological Survey as setting a desirable standard. In such areas, most of the structure can be represented adequately by structure contour lines, but there might perhaps be need for further attention to dips of faults, distribution of fractures, and other features that sometimes escape notice.

3. *Detailed study of salt domes.*—M. K. Hubbert outlines a program for a detailed study of salt domes. The most important part of the work would be a structural study of exposures in mine workings in the domes, there being such workings in five or six of them. These exposures show flow structure and other features of the salt core that would be capable of observation and analysis after the fashion of similar observations that have been made on igneous intrusions. This information could then be fitted into its proper setting in the dome as a whole by use of oil company drill records and other data. Hubbert states

that Professor Robert Balk is interested in undertaking such a project. It would require a grant of research funds and the cooperation of various mining and oil companies.

In connection with detailed study of salt domes, Hubbert calls attention to a paper by O. Wilhelm presented at the 1945 meeting of the American Geophysical Union, and now nearly ready for publication. He states that this represents one of the most detailed studies of the faulting associated with salt dome structure made so far, and is based almost entirely on the results of drilling.

4. *Detailed studies of other oil-bearing structures.*—Hubbert's proposal suggests to the writer that other types of oil-bearing structures (anticlines, domes, fault blocks, *et cetera*) might repay similar structural analysis, with a view of adding to our knowledge of the mechanics of their formation. As underground workings are not present on most of them, such studies would consist largely of observations at the surface of fracture systems, faults, minor folds, *et cetera*. Possibly features known to be representative of a general type and characterized by exceptionally good exposures could be selected. An example of such work is that done in the Kettleman Hills by the United States Geological Survey.⁶ This subject overlaps on that of a proposed study of the regional distribution of fracture systems that is discussed under a later heading (10).

In this connection, Robert Balk suggests:

... that we organize somewhere a clearinghouse of information on *unusually well exposed areas*. Being essentially a free-lance in my field work, my constant worry when starting a new problem is: if only exposures will be good! I suspect that in the aggregate our fraternity wastes much time (as far as structural questions are under investigation) in poorly exposed areas. This is particularly true in fracture studies. For work on joints, exposures cannot be too good. If we had some very good monographs on exceptionally exposed areas, I think they would be of much general value, regardless of where the region in question may be.

S. W. Lowman points out that a new volume on the structure of typical oil fields is being planned by the Association and that a study of volumes previously published would be desirable with a view of determining what new subjects need to be treated, wherein the older papers need revision, and how classification of oil-bearing structures can be improved. Wilhelm's⁷ recent paper is a notable contribution to classification of oil-bearing reservoirs, but further work is needed on the classification of oil-bearing structures.

Some additional suggestions have been made in regard to the study of oil-bearing structures which have a closer connection with the accumulation of oil and gas. Lowman suggests the need for study of the variations in the amount of closure needed for oil and gas accumulation; in the Rocky Mountains, closures up to 400 feet seem to be necessary, while in some other areas very low structures are completely filled. M. G. Cheney suggests the need for a comparison of oil-bearing structures with seemingly comparable structures that contain no oil. Does the difference lie in the structural history of the respective features, especially during the critical period of generation of the oil from the source rocks? Considerable work has been done on this subject in the mid-continent and Gulf Coast areas, but other oil provinces have probably not been studied with this problem in mind.

REGIONAL PROJECTS

Under the heading of regional projects are grouped those which deal with some one of the larger subdivisions of the continent (oil provinces, tectonic units of the first order, *et cetera*.) In general, regional projects involve the second type of research listed above—asssemblage and synthesis of facts, the basic facts being derived from local studies of the

⁶ W. P. Woodring, Ralph Stewart, and R. W. Richards, "Geology of the Kettleman Hills Oil Field, California," *U. S. Geol. Survey Prof. Paper 195* (1940), Pl. 51.

⁷ O. Wilhelm, "Classification of Petroleum Reservoirs," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 29 (1945), pp. 1537-79.

sort discussed above. Most regional projects involve stratigraphy as much as they do tectonics and serve to stress the close interrelation of the two fields.

Regional projects seem to offer the most immediate promise for the discovery of petroleum. By now, most of the obvious surface indications for petroleum have been tested, and further exploration must be for less obvious structural and stratigraphic traps, the main clues to which are obtained from regional geologic relations, and from the geologic history of the region.

Some regional studies are carried on by oil companies, and large amounts of information have no doubt been summarized by them in the form of various types of maps. The writer has the impression, however, that such work is not necessarily comprehensive and that it is usually carried on incidentally to more immediate and more routine work. It would therefore seem that much of value could be accomplished by cooperative projects among oil company geologists, by study groups of local societies, by public agencies, and by other research groups. In this connection, R. A. Liddle writes:

Such studies can best be carried on by local geological societies because most of the information is already in the files of oil companies operating in such regions. . . . Cooperation of company geologists, and sponsorship by local geological societies, should make possible the completion of a project . . . in a year or two. Projects which run through several years and administrations suffer from changing factors and interests.

5. *Geologic maps of states.*—Geologic maps of many of the states have been published, mostly on a scale of 1:500,000, and these are a valuable source of regional information. Such maps are generally assembled by plotting all available published information; adding to it manuscript maps, in part contributed by oil-company and mining geologists; and finally by reconnaissance surveys by the compiler and editor, to fill in blank spaces and to reconcile and unify the existing data.

For some states, no geologic maps have been prepared (for example, Oregon, Nevada, and North Carolina). For some of these states, so much material is now available that little more than compilation, editing, and drafting are needed. For others, such as Nevada, much more original areal mapping is needed if an adequate portrayal of the geology were to be made on the 1:500,000 scale.

Many of the existing state maps are in need of revision, as they are not on standard scale, are too generalized, or do not show the results of recent detailed surveys. Some of the older maps also do not adequately portray the structure; on the 1:500,000 scale it should be possible to show the gross fault pattern and the prominent anticlinal axes.

An example of a State map needing revision is that of Wyoming, published in 1925. This embodies much detailed published material, and many reconnaissance surveys by oil companies and others, but considerable areas were filled in from maps of the old territorial surveys, land classification maps, and other exploratory data. Subsequent to publication, detailed and reconnaissance maps have been published for many more areas, and other maps are no doubt available in manuscript. It would be desirable that the remaining, still poorly known areas be filled in by reconnaissance work.

Plans are being made by the United States Geological Survey and the State Surveys for completion and revision of the state map series, and the sub-committee on tectonics recommends that this project be completed.

6. *Geologic structure maps of states.*—Several State Surveys have published geologic structure maps of their states, which are similar in plan to the tectonic map of the United States, but on a larger scale. Such maps generally show structure contours on several horizons, faults, axes, oil and gas fields, and similar features. The geologic structure map of Kentucky is on a scale of 1:500,000, and the current edition of that of Texas on 1:1,000,000. According to J. T. Lonsdale, a revised edition of the map of Texas on a scale of 1:500,000 is nearly ready for printing and will show structure contours on 12 horizons. According to R. H. Dott, compilation of a structure map of Oklahoma is in progress; most of the state

will be contoured on the Viola limestone, but contours on other horizons will be added in certain areas. According to A. H. Bell, no comprehensive structure map of the state of Illinois is being planned, but large fractions of the state have been contoured on various horizons, much of this work being still in manuscript. A structure map contoured on the base of the Kinderhook-New Albany shale and covering about three-fourths of the state has been published.^{7a}

The preparation of geologic structure maps of states by the appropriate State geological surveys is a project that deserves commendation.

In this connection, geologists engaged in exploring for zinc and lead deposits in the folded and faulted Paleozoic rocks of the Appalachian Valley in Tennessee and Virginia have indicated to the writer that a tectonic map of this area on a scale of 1:250,000 or 1:500,000 would be a great aid in their work. The occurrence of zinc and lead deposits in this area is controlled to an important degree by structural relations, and knowledge of the regional pattern is important in prospecting. All this area is covered by geologic maps, but many of these are not up to modern standards, so that extensive new surveys and a critical review of the structural features would be necessary to produce a tectonic map of real value.

7. *Comprehensive studies of regions.*—Comprehensive studies of regions involve a synthesis of all facts that will elucidate the present geological condition of a region, and its evolution through geologic time.

Studies of this type have been made ever since geologists began to wonder about the broader significance of the local features they were observing, but the results have varied widely in character. Earlier studies were based on too little information to be of value now. Many have emphasized only stratigraphy, paleogeography, or structure and have not considered the interrelations of the subjects. Many are the results of single workers, some of whom are avowedly not objective, but attempt to set forth and demonstrate a thesis. Many studies consist largely of text and lack adequate illustrative material.

The type of comprehensive study of interest to us here is the result of cooperative rather than of individual effort and is based not only on surface mapping but on subsurface work. Presentation is largely objective, the inferences not passing beyond those that can reasonably be drawn from the factual data. The results of the study appear largely in the form of maps, charts, sections, and other illustrative matter that present the data in graphic, comprehensible form. The text (if any) serves as a commentary. An example of this type of work is that of Reed and Hollister⁸ in southern California. The methods employed in this work are a worth while model for further studies in the same and other areas.

Many types of plotting are possible in order to bring out the structure, stratigraphy, and paleogeography in graphic form. These include the following:

1. Contour maps on successive horizons, starting with the basement if possible, to bring out differences between successive "layers" in "layer-cake geology," or differences between important subdivisions of a single "layer."
2. Isopach maps, showing present thicknesses of "layers" in "layer-cake geology," important subdivisions of single "layers," or "stages" of the geologic systems.
3. Facies maps, showing depositional facies, especially those of tectonic significance, for each "stage" of the geologic systems. Such maps could also show (more subjectively) the nature of the adjacent lands (whether high or low), and structural features known to have been formed during the "stage."

^{7a} A. H. Bell, "Subsurface Structure of the Base of the Kinderhook-New Albany Shale in Central and Southern Illinois," *Illinois Geol. Survey Rept. Inves.* 92 (1943).

⁸ R. D. Reed and J. S. Hollister, "Structural Evolution of Southern California," *Bull. Assoc. Petrol. Geol.*, Vol. 20 (1936), pp. 159-1692.

4. Paleogeologic maps on surface of each important unconformity.
5. Paleogeographic maps, largely combinations of the above four types, but with more subjective treatment. Presentation would be considerably more detailed than in conventional text-book maps of this type, and with main emphasis on tectonic development. Where considerable crustal shortening has taken place, this should be taken into consideration, following methods suggested by Kay.⁹

6. Charts showing time relations of orogeny, epeirogeny, transgressions, regressions, etc. in different parts of region, similar to those prepared by Reed and Hollister for southern California. In many regions such events are relatively uniform throughout the region. In others, they are variable and difficult to visualize (Tertiary of southern California, Laramide of Rocky Mountains, later Paleozoic of southern Oklahoma).

Variations of these types of plotting have been suggested by various geologists. Lowman points out that for some unconformities a map showing the geology of the surface above the unconformity would be quite as significant as a map showing the geology below it. R. A. Liddle suggests a series of maps showing the existing surface and subsurface extent of each group of strata in the region, along with the location of major tectonic features, structure contours, *et cetera*. As such maps would be confined to existing features, they would be more objective than the paleogeographic maps listed above. Perry Olcott suggests the preparation of "geodatum maps":

What I have in mind is to slice the earth at sea level, for instance, and show the distribution of the various formations at that level. After that map is completed, step down to 1000 feet below sea level and up to 1,000 feet above sea level, and show what the areal geology of the United States would be if all the surface were removed to those levels. . . . A series of about 14 of these maps from 4,000 feet above sea level to 10,000 feet below sea level would be invaluable to geologists and mining engineers of all kinds.

No doubt other and equally ingenious methods of assembling and plotting information will occur to other geologists.

Comprehensive studies of regions can be undertaken in almost any of the oil provinces of the United States. The preliminary report of the research committee, of January, 1946, contains the following suggested projects which are related to this scheme.

1. Basin-edge structure and overthrusting in southern Oklahoma (by Ardmore Geological Society)
2. The Arbuckle-Ouachita facies change (by Ardmore Geological Society)
3. A tectonic study of structures in Wyoming and adjacent states (by Wyoming Geological Association)
4. Pre-Laramide folding in Rocky Mountains (by Wyoming Geological Association)
5. The Ouachita-Marathon trend—does it exist? (by West Texas Geological Society)
6. Various problems of the Gulf Coast area, largely stratigraphic but with tectonic implications (by S. W. Lowman)
7. Various problems of salt domes (by M. A. Hanna)
8. A comprehensive tectonic and stratigraphic study of the East Texas embayment (by R. A. Liddle) (Compare with "Research Problems, East Texas Area" by East Texas Geological Society)

As pointed out by S. W. Lowman, two of the provinces offer exceptional opportunities for study, the Los Angeles area and the Gulf Coast area. Here a comparison is possible between past (Tertiary) and modern conditions and processes. In each, sedimentation possibly similar to that of the late Tertiary still continues offshore, thus making possible a correlation between processes observed in oceanographic work with processes to be inferred from outcrops and subsurface data on the land. The two regions differ considerably in character between themselves, the Los Angeles area being much more mobile tectoni-

⁹ Marshall Kay, "Paleogeographic and Palinspastic Maps," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 29 (1945), pp. 433-42.

cally than the Gulf Coast. An opportunity is thus available for studying contrasting types of sedimentation and tectonics.

In the Los Angeles basin, according to A. O. Woodford,

it is probable, on the basis of the foraminiferal and molluscan facies, that a large part of the basin was 5,000 to 6,000 feet deep at the beginning of the Pliocene, and that there was slow filling during the Pliocene and early Pleistocene, with local deformation but without general sinking of the floor.

This interpretation adds significance to the frequently made comparison between this Tertiary basin and the "basin and range province"¹⁰ immediately offshore, with its deep basins, intervening platforms and ridges, and occasional islands. Research on sedimentation and tectonics leading to a comparison between the ancient and modern examples would seem to be desirable.

S. W. Lowman also discusses the need for further research upon "basin-edge structures and partly overthrust rims," with particular reference to California and the Rocky Mountains:

These . . . would appear to be the combined result of forces generated within the sedimentary mass and the reaction of that mass to forces transmitted through the basement. Even a partial resolution of these two sets of forces should contribute to an understanding of the mechanics of deformation of the basins.

In other provinces, such as Wyoming (where the active tectonic phase was in the Mesozoic and early Tertiary) and in southern Oklahoma (where the active tectonic phase was in the Paleozoic) comparisons with modern features are more remote, but erosion has been carried to deeper levels, thus exposing features of the tectonics that are not accessible in the examples just cited.

Some oil companies are carrying on regional studies as a part of their program of oil finding. J. E. Adams describes one such project as follows.

Right now I am working on a contour map of the basement in Texas and New Mexico with a slice of the adjoining areas. We use the U. S. G. S. base shot down to 10 miles to the inch for convenience in spotting. We are reducing the regional geophysical maps to the same scale. After I finish the basement base map, I want to use it as a vehicle for isopach, facies, paleogeology, and other projects. It should be a year and a half or two years work, even with help from the district offices. Maybe when we get there we can show the management why we favor structures in some areas and not in others. More important, we may even know why ourselves.

8. *Work of Fuels Section of United States Geological Survey.*—As a phase of the war activities of the Geological Survey, the Fuels Section, under the direction of H. D. Miser, has carried out an expanded program of oil and gas investigations. This work is still in progress. Prompt publication of results is maintained by the issuing of preliminary maps and charts. The investigations have been planned so as to supplement rather than duplicate the work done by oil companies, and much emphasis has been placed on regional studies, and on the preparation of contour and isopach maps of the sort described in the previous paragraph.

An outstanding example of the work done is a set of 7 maps and sections of the Forest City basin Missouri, Kansas, Nebraska, and Iowa. The maps show isopachs on successive stratigraphic units, and the paleogeology of the surfaces of unconformities. The sections show the progressive development of the structural features.¹¹ Another series deals with successive stratigraphic units in the Michigan basin,¹² and still another with a single stratigraphic unit, the Berea sand, throughout its extent in Ohio, Pennsylvania, and West Virginia.¹³

¹⁰ F. P. Shepard and K. O. Emery, "Submarine Topography Off the California Coast," *Geol. Soc. America Spec. Paper* 31 (1941), p. 9.

¹¹ *U. S. Geol. Survey Prelim. Map* 48, Oil and Gas Investig. Ser. (1946). 7 sheets.

¹² *Ibid.*, *Prelim. maps* 11, 17, 28, 38, and 46 (1944-1946).

¹³ *Ibid.*, *Prelim. maps* 5, 9, 29, and 39 (1944-1945).

The work of the Fuels Section is to be commended, and further publications of the Oil and Gas Investigations Series will be awaited with interest.

9. *Work of Yellowstone-Bighorn Research Association.*—The Yellowstone-Bighorn Research Association has carried on a regional study in northwestern Wyoming and southwestern Montana since 1930. The methods used are different from those hitherto discussed, and deserve description for their possible application to other regions and problems. Organization of the Association is largely due to the efforts of Professor W. T. Thom, Jr., of Princeton University, who has supplied most of the data given in the following paragraphs.

Operations of the Association are a phase of University work, field work being done during the summer from headquarters at Red Lodge, Montana, and office and laboratory work during the academic year at the respective universities. Participants include faculty members of several universities (the personnel changing from year to year), graduate students working on dissertations, undergraduate students, preparatory school students, and visitors. Many phases of the structure, stratigraphy, geomorphology, and geophysics of the region are studied, but chief emphasis has always been toward obtaining a synthesis of the tectonics. As the region is one of mountain uplifts and intermontane basins in a critical segment of the Rocky Mountains, considerable contributions are possible to general knowledge of tectonics.

Most of the work consists of mapping of surface formations and structure, reports on individual units appearing in various periodicals. The United States Coast and Geodetic Survey has cooperated by establishing gravity stations in critical areas. Several summaries of the work have been published¹⁴ and a monographic summary of the structural geology and structural evolution of the region is planned.

Work of the Association has continued on a reduced scale during the war, but plans for resumption of normal operations in the post-war period are being made. The past work of the Association is to be commended, and geologists will look forward to another fruitful period of activity on the part of the Association in the post-war period.

10. *Studies of fracture systems.*—A subject on which very little is known is the regional extent and pattern of fracture systems in the United States. The distribution of faults is fairly well shown on state geologic maps and elsewhere. The occurrence of minor breaks, or joints, generally without displacement and present both in faulted and non-faulted areas has been recorded only here and there. The writer has found that observations on joints are helpful in field work. With these observations in hand, it is apparent that faulting in an area is only half the story. Joints follow the same trends as the major faults, even miles away from them, and stray faults of odd trends prove to be the expression of widespread, important systems of jointing.

Similar revelations on a grander scale might become apparent when joint systems of a whole region are assembled. In strongly deformed or metamorphosed terranes, jointing is doubtless complex, with dips at all angles and in all directions, and with the patterns related perhaps more to local stresses than to regional forces. But in the gently dipping rocks of the vast central interior of the United States, joints generally stand nearly vertically and have systematic patterns over wide areas.

Perhaps the most comprehensive work that has been done on the regional extent of jointing is that of Melton in Oklahoma,¹⁵ which work was later extended into adjacent states. Melton's work was avowedly reconnaissance, and although outcrops used were carefully selected, they were widely spaced. Recently, an elaborate study of jointing in 24

¹⁴ W. H. Bucher, W. T. Thom, Jr., and R. T. Chamberlin, "Symposium: Geologic Problems of the Beartooth-Bighorn Region," *Bull. Geol. Soc. America*, Vol. 45 (1934) pp. 167-88.

—, "Results of Structural Research in Beartooth-Bighorn Region," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 17 (1933), pp. 680-93.

¹⁵ F. A. Melton, "A Reconnaissance of the Joint Systems of the Ouachita Mountains and Central Plains of Oklahoma," *Jour. Geol.*, Vol. 37 (1929), pp. 729-46; and later papers.

quadrangles in east-central New York state has been published,¹⁶ and also analysis of joints in two adjacent areas in West Texas with a total area of about 1,600 square miles.¹⁷

One possible means of filling in the character of the fractures between better known areas (at least in the arid southwest) is by use of air photographs. The writer has recently had occasion to examine a large collection of such photographs from West Texas, and has been impressed with the manner in which fracture systems are displayed, with their relations to faults, with variations in spacing and intensity, and with the setting in and dying out of different fracture systems as one proceeds across the area. Such studies, of course, give no information on the physical character of the fractures or other details; these can only be determined on the ground. But they do furnish many clues as to the regional pattern. Similar work has been done by Melton and by D. C. Barton.

Studies of fracture systems need more standardization than they now possess. More uniform rules of field procedure are desirable—how to observe and what to observe. Similarly, methods of analysis and plotting of observations need to be unified so that the large masses of observations can be summarized in understandable form, and so that observations of one worker will be comparable to those of another.

The sub-committee on tectonics would like to see the formulation of projects that would deal with fracture systems, both in their relation to local geology, and in their regional extent. Such formulation might be stimulated by the publication of more of the data that probably are now available, with attention called to problems as yet unsolved.

INTERREGIONAL PROJECTS

Interregional projects resemble regional projects in that they are largely syntheses of factual material, designed to bring out the character of tectonic features of the first order. Instead of dealing with individual provinces or regions, they deal with the continent as a whole or larger parts, hence material is assembled on a smaller scale and with a greater degree of generalization than in the regional projects. Such projects illustrate the character of oil provinces and their interrelation, and may lead to the discovery and appraisal of prospective oil provinces. Some hint of their value is suggested by the popularity of the recently published Tectonic Map of the United States.

11. *Revision of Tectonic Map of United States.*—The tectonic map of the United States was printed and issued in 1944. It was compiled and assembled by the Committee on Tectonics of the National Research Council, under the chairmanship of C. R. Longwell, and is published and distributed by the American Association of Petroleum Geologists. Much aid in the final revision of the map was also given by the Association and its affiliated societies.¹⁸

Since publication of the map, over half the edition of 5,000 copies has been sold. The plates have been preserved by the lithographers so that reprintings are possible. The popularity of the map has, however, suggested the desirability of a revised edition some years hence. The Committee on Tectonics is therefore being reorganized as the Committee on the Tectonic Map of the United States, and is making plans for a revision.

The main revisions will, of course, be the addition of information that has come to light since the present edition of the map was compiled. Well drilling is constantly adding new subsurface data, which will require the shifting of the structure contours as represented, or

¹⁶ J. M. Parker III, "Regional Systemic Jointing in Slightly Deformed Sedimentary Rocks," *Bull. Geol. Soc. America*, Vol. 53 (1942), pp. 381-408.

¹⁷ U. S. Geol. Survey Prelim. maps 2 and 8, Oil and Gas Investig. Ser. (1944).

¹⁸ For a history of the map project, and other information, see C. R. Longwell, "Tectonic Map of the United States," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 28 (1944), pp. 1767-74.

may even suggest the need for adopting a new datum in certain areas. Much areal mapping is also in progress which may require changes in representation of the mountain areas. Thus the new geologic map of Idaho, now in press, will no doubt contain many new data of tectonic significance. A. C. Waters also points out that strategic mineral investigations by the United States Geological Survey and others in the tectonically important but poorly known Coast Ranges north of San Francisco will introduce many changes in the structural representation of that area.

In addition, reappraisal of existing information in certain areas as shown on the map would be desirable. Due to wartime pressure, the geologic publications on certain complex areas such as New England and the Canadian shield could not be as thoroughly reviewed as one might wish. Further restudy of the published material, and criticism by specialists on those areas would seem to be in order.

One possible source of information deserving exploration is the air photographs of poorly known regions that have been made by government agencies during the war. Especially helpful for obtaining a regional view are the trimetrogon pictures, taken from a high level, and including both vertical and oblique views. Much of the area in northern Mexico shown on the present tectonic map has been so covered, and the photographs of this area could be used to extend the information known from ground surveys.

In regard to revisions of the map, and preparation of similar maps, Stebinger¹⁹ writes:

Every geologic map is essentially a report of progress, picturing the facts known at the time of its preparation, and it is subject to corresponding limitations. This is particularly true of a compilation of this character. It is evident that the attempt to portray on a single map the orogenies of the earth's long history in their proper time sequence, over a considerable area, inevitably leads to many compromises and shortcomings in presentation. Future attempts for the United States might well be laid out on separate maps, grouping the tectonic features leading up to, and climaxing in, each of the great orogenies. As the information increases, particularly on the superimposed orogenies buried in the basin areas, the detail will inevitably become too complex for a single map. . . . For a long time to come, American geologists must necessarily be offering revisions of their present attempt and should ultimately aim at a comparable tectonic map for North America as a whole.

Ernst Cloos, in commenting on the map, stresses the lack of detailed information (at least in many areas) and suggests that the small scale serves to hide many deficiencies:

The tectonic map is a fine job, but in order to be really useful and to provide data on which further work can be done the scale should be larger. I should like to see somebody assembling all structural data; that is, fold axes, joints, faults, etc. on a 1:1,000,000 scale. If the scale is too small, the gaps in our knowledge will not appear and the tectonic maps of North America look unfortunately as if we knew a lot which we don't. . . . As a matter of fact, if you have ever tried to take a base like 1:1,000,000 you will immediately see that there is little you can put on. I think a project like this should bring out what we don't know as much as what we know.

This suggestion would seem to be met, at least in part, by the proposal for geologic structure maps of states that was discussed under an earlier heading (6).

12. *Related projects.*—Revision of the tectonic map implies the retention, with little modification, of the same scale, area, symbols, and method of treatment as on the present map. In addition, proposals have been made for extending the area to be covered, or for different methods of treatment. Some of these suggestions are embodied in the quotation from Stebinger, given above.

Extension of the present tectonic representation to include lands to the north and south of the continental United States would be desirable. It would not only aid in petroleum and other economic exploration, but would add greatly to the perspective in tectonics of American geologists. Many of us tend to theorize on our geology and tectonics

¹⁹ Eugene Stebinger, "Review of Tectonic Map of United States," *Geog. Rev.*, Vol. 35 (1945), pp. 689-90.

without considering adequately the very important bearing on the subject possessed by the lands north and south of us.

Compilation of such data should lead eventually to the preparation of a tectonic map of North America, which would be a companion of the new geologic map of North America on the 1:5,000,000 scale, just as the present tectonic map is a companion of the geologic map of the United States on the 1:2,500,000 scale. This proposal may be premature at present, but as an intermediate stage, it would be desirable to begin compilation of tectonic maps of Canada, Mexico, Alaska, and other large units of the continent.

Proposals for new methods of treatment are based on one of the most serious weaknesses of the present tectonic map (at least in the contoured areas). Here, presentation tends to be selective, for only one horizon is contoured in an area. If "layer cake geology" exists, the structure of only one "layer" can be shown. Thus, in central Texas, the present map shows structure contours on the base of the Mississippian, which indicates a broad arch. Contours on the overlying Pennsylvanian would show a northwest dip, and contours on the still higher Cretaceous a southeast dip.

The solution for this problem would seem to lie in a series of maps showing present structure on different horizons, or maps showing the historical development of the structure. Maps of this type have already been described and listed under "Comprehensive studies of regions" (7). Probably the time is not yet at hand for uniform treatment of this type, covering the entire country, and the writer believes that best progress along these lines will come from studies of individual regions, as outlined under (7).

13. *Contour map of United States on top of basement rocks.*—The Special Committee on Geophysical and Geological Study of Continents of the American Geophysical Union under the chairmanship of W. T. Thom, Jr., has announced as one of its objectives in the near future the preparation of a map showing the configuration of the basement rocks in the United States. This project is to be commended.

The Committee on Continents was organized in 1935, under the chairmanship of Professor Thom, to work with two related committees of the American Geophysical Union, the Committee on Geophysical and Geological Study of Ocean Basins, and the Committee on Cosmic-Terrestrial Relationships, and with corresponding committees of the International Union of Geodesy and Geophysics. According to R. M. Field, "The personnel or membership of these committees has changed from year to year, but always with due consideration to the interrelation of the work of the three committees." In 1945, membership in the Committee on Continents was expanded, and a number of projects outlined for study, including that under discussion.

Several maps showing configuration of the basement rocks in small or large parts of the United States have been prepared and published, including one by Moss²⁰ in 1934, and another by the Committee on Continents in 1939. According to Thom, the history of the latter has been as follows.

Since the seismic (refraction) method and other geophysical exploratory techniques may yield results which relate particularly to the configuration and structure of the surface of the basement complex, and since a three-dimensional model is much more easily readable than a structure contour map, one of the first endeavors of the Special Committee on Continents was to assemble a reconnaissance contour map—for the area between the Rocky Mountain front and the Atlantic Coast—in order that a "basement surface" relief model of this region could be constructed. This map and model were exhibited at the American Geophysical Union's annual meetings in April, 1936, and at the Sixth General Assembly of the International Union of Geodesy and Geophysics held in Edinburgh during the summer of 1936. Subsequently this basement map was revised and was extended westward to the edge of of Great Basin to include western Wyoming, eastern Idaho, and western Montana, and a new relief model was made—the map and model constituting, respectively, Special Exhibits 1 and 50 prepared

²⁰ R. G. Moss, "Buried Pre-Cambrian Surface in the United States," *Bull. Geol. Soc. America*, Vol. 47 (1934), pp. 935-66.

by the American Geophysical Union for display at the Seventh General Assembly of the International Union held in Washington in September, 1939.

A revision of these published maps would seem to be both possible and desirable. Deep wells have in recent years penetrated the basement at many more places than hitherto, and where they have not penetrated basement they have furnished data about deep-lying strata that would aid in calculating the depth of the basement. Such a map would be a useful companion of the tectonic map, in that it would reduce all the features shown thereon to a common datum. It would also be helpful for reference in geophysical work.

On any new map of this type, the writer suggests that different sorts of basement be differentiated in some manner, perhaps by different colors of contour lines. In the Central Interior Region and Rocky Mountains the top of the basement is the eroded surface of the pre-Cambrian, but elsewhere it may be of younger ages. On the west coast, if a surface could be contoured, it might be of Mesozoic age. In the Atlantic and Gulf Coastal Plains, it is the buried extension of the Piedmont surface. Proceeding eastward and southeastward from the Central Interior the top of the pre-Cambrian basement and its Paleozoic mantle is more and more deformed, and finally in the Piedmont it is deeply infolded in the metamorphic terrane, and cut off in places by Paleozoic batholiths. The surface contoured in the Coastal Plain is thus the top of a complex of pre-Cambrian and Paleozoic rocks.

W. H. Monroe points out that in the eastern Gulf Coastal Plain this surface is not reached by wells more than a short distance downdip from its outcrop, and that extrapolation is hazardous because of the seaward thickening of all the Mesozoic and Tertiary formations, and because of the marked unconformities between some of the Mesozoic groups:

No contour map of the basement is possible in the Gulf States, except in southern Georgia and northern Florida, because of unknown thicknesses of Lower Cretaceous, Jurassic, and Paleozoic rocks.

14. *Distribution of North American geosynclines in time and space.*—The study of geosynclines is mainly stratigraphic, but deserves mention here because of its tectonic implications. Study of North American geosynclines has been given new impetus in recent years by Kay²¹ who has subdivided geosynclines into five types, and who points out that in geosynclinal belts the different types may be superimposed on each other in many arrangements. With the aid of these new concepts, it is desirable that the time and space relations of the different types be determined, and Kay has been working on a series of sequential maps on which the extent of the different types of geosynclines is indicated.

GEOPHYSICAL PROJECTS

Research in geophysics is being discussed by a sub-committee on that subject, but it seems worth while at this place to discuss briefly projects leading to results in tectonics which must be accomplished largely by geophysical methods.

15. *Gravimetric map of United States.*—The United States Coast and Geodetic Survey has from time to time published maps showing variations in the value of gravity in the United States. Such maps have been based on pendulum stations, for the most part widely spaced, and set up to aid in determination of the best parameters of the spheroid of reference to be used in the reduction of the triangulation network.

Much more detailed work has been done in parts of the country, partly by increasing the density of the pendulum stations, and partly by gravity meter traverses. M. K. Hubbert suggests that similar treatment be extended to the remainder of the country. This project is summarized as follows.

Increase of density of gravimetric base stations to one station to 2,500 square miles; interconnect

²¹ Marshall Kay, "Geosynclines in Continental Development," *Science* (June 9, 1944), pp. 461-62; and subsequent papers.

pendulum stations with gravity meter traverses and adjust network to 0.1 milligal accuracy; run gravity meter profiles across major second-order gravity anomalies and across major tectonic features of the United States.

This project is recommended by the research committee.

16. *Magnetic map of the United States.*—A similar map might be prepared, showing in more detail than hitherto the variations in the value of magnetism in the United States. As Hubbert points out, use of the airborne magnetometer will greatly increase the rapidity with which the basic data could be assembled.

17. *Tectonic data from level lines and triangulation nets.*—Level lines and triangulation nets of the United States Coast and Geodetic Survey furnish one of the main clues as to deformation now in progress in the United States. Further collaboration between geologists and this Survey, and use of the Survey's results by geologists would be desirable. In this connection, James Gilluly makes the following comment.

Many useful tectonic data are contained in the U. S. Coast and Geodetic Survey level lines, especially in California. Many of these lines have been run over again at intervals of some years, and the original field notes show significant differences in the vicinity of folds and faults. These differences are generally smoothed out or eliminated in final calculations and adjustments. It is suggested that both adjusted elevations and original field elevations be made available for use of students of tectonics.

18. *Oceanographic studies.*—Mention has been made that in our thinking regarding tectonics in the United States we often tend to ignore the effects of the tectonics of the lands to the north and south of us. Another "blind spot" in our thinking is the submerged offshore areas. Here, because the geology and tectonics can not be worked out by direct observation, recourse must be had to various geophysical methods.

The importance of such work to tectonics is illustrated by the revolutionary discovery of Meinesz²² that the axes of mobile belts at sea are characterized by large negative anomalies. Equally interesting are the studies of submarine canyons, although their tectonic implications are more remote. To petroleum geologists, chief interest attaches to studies of the continental shelves, which are widely believed to contain large reserves of oil. Exploration of the geology of the continental shelves would seem to have practical as well as theoretical interest.

One of the most promising investigations of the continental shelves so far made is that of Ewing and others²³ off the Atlantic coast. Two seismic cross sections were made, starting on land and extending 100 miles or more seaward. The results indicate the configuration along the lines of the cross sections, of the surface of the crystalline basement rocks, and the relations of overlying semi-consolidated and unconsolidated rocks. It is reported that further work of this type has been done for government agencies during the war, and J. A. Sharpe states that various oil companies plan to make geophysical studies of the shelf areas in the course of their exploration for petroleum.

GENERAL AND THEORETICAL PROJECTS

Consideration will now be given to projects involving the third type of research in tectonics—research leading to the interpretation of facts. The reader will recall a plea by Hubbert, quoted earlier in this report, calling for study and experimentation (as opposed

²² F. A. Vening Meinesz, "Marine Gravity Survey in the Netherlands East Indies: Tentative Interpretation of Provisional Results," *Proc. Kon. Akad. Wetensch.*, Vol. 33, pp. 566-77. Amsterdam (1930).

—, "Gravity Anomalies in the East Indian Archipelago," *Geog. Jour.*, Vol. 77 (1931), pp. 323-49.

And other papers.

²³ Maurice Ewing and others, "Geophysical Investigations in the Emerged and Submerged Atlantic Coastal Plain," *Bull. Geol. Soc. America*, Vol. 48 (1937), pp. 753-812.

to mere speculation) on the origin of structural features, making use of mechanical and other principles that have been developed in the physical sciences.

This section of the report is shorter than those which have gone before. This is not because the writer is out of sympathy with this type of work, but partly because his knowledge of it is slight, for his training and interests (like those of many other geologists) have been in fact-finding and synthesis. Also, the subject has been well covered in a report of the National Research Council by a sub-committee of the Interdivisional Committee on Borderland Fields between Geology, Physics, and Chemistry.²⁴ Parts of this report are here quoted, but for further information the reader is referred to the original.

General nature of the problem.—The general nature of the problem is summarized as follows by the Research Council sub-committee.²⁵

The study of the deformation of rocks is but one division of the general subject: the mechanics of deformable bodies. The mechanics of fluids is another branch of the same subject. The mechanics of deformable bodies, far from being in its infancy, has been cultivated with ever increasing intensity for somewhat more than a hundred and fifty years, first by the physicists and more recently by the engineers, particularly in the field of hydrodynamics, aerodynamics, and soil mechanics. During that time methods of experiment and of description and analysis have been evolved which have proved indispensable to students of the various branches of the subject. . . .

An understanding of rock deformation is a matter of fundamental importance to geologists. Rock deformation is a physical phenomenon, however, and if one is to proceed to its study beyond the stage of elementary description the language and the tools developed by the physicist for problems of this kind are indispensable.

On the purely mechanical side of the problem, the study of deformations consists principally of two stages (1) an accurate description of deformation and (2) a dynamic study wherein the forces accompanying the deformation are taken into account. In addition to these there is a thermodynamic aspect of the problem, particularly in those cases in which the materials being deformed undergo changes in phase during the process. The latter is a common phenomenon accompanying deformation of rocks, leading to the mineral changes of the sort occurring in dynamo-metamorphism. . . .

There is great need for field studies of regional deformations employing these more precise methods of analysis and description. Such studies should embrace both contemporary deformation and strains that occurred in the past. The data must be obtained from the field; the methods of description and analysis have already been perfected. . . .

The logical approach to the problem seems to require the following major steps:

1. Become familiar with the methods of analysis and experiment that are used successfully in the related fields of elasticity, plasticity, soil mechanics, and fluid mechanics.
2. Borrow as much of this as is applicable to the problem of rock deformation and apply it to existing geological field and laboratory data on rocks. This should enable one to evaluate the adequacy of existing data and show precisely what new data are needed most.
3. In the light of this evaluation, obtain from the field and from the laboratory the further data required, and repeat the solution.

19. *Field projects.*—The Research Council sub-committee lists the following classes of field projects as deserving study.²⁶

1. Regional determinations of the kinematical elements of contemporary strains as in (1) regions undergoing orogenic movements (such as southern California), and (2) regions undergoing epeirogenic movements such as the post-glacial uplift. (It is suggested that the analysis of such movements be carried out by analytical methods applicable to vector fields. . . .) The field methods to be used vary with the different problems. They include periodic repetition of precise triangulation and level networks, tide gauge stations, shoreline studies, tilt meters, and integration of strong earthquake records. . . .

2. Measurements of local elastic strains of rocks in quarries and excavations by means of strain gauges, and analysis of measured strains to obtain magnitude and orientation of stress tensor.

²⁴ M. K. Hubbert, W. H. Bucher, D. T. Griggs, and A. Nadai, "Deformation and Rupture of Geological Materials; Report of Sub-Committee on Rock Deformation," in *Report of Interdivisional Committee on Borderland Fields between Geology, Physics, and Chemistry*, Nat. Research Council, Div. of Geol. and Geog. (1938), pp. 12-20.

²⁵ *Ibid.*, pp. 12, 14, and 17.

²⁶ *Ibid.*, pp. 18-19.

3. Regional mapping of past geologic strains by methods applicable to vector fields: a) mapping of strains, b) Determination of unstrained state. . . .
4. Field mapping of flow lines, foliation, joints, etc. . . .

Some of these projects resemble or duplicate those suggested earlier in this report. Thus, item 1 includes project 17, tectonic data from level lines and triangulation nets. Item 4 includes project 3, detailed study of salt domes; project 4, detailed study of other oil-bearing structures; and project 10, studies of fracture systems.

Mention should be made here of research in petrofabrics, or the detailed field and microscopic study of mineral orientation in rocks, and explanation of it as in part due to deformation. Most research on the subject is not of interest to the present sub-committee, as it deals mainly with igneous and metamorphic rocks, and with rocks that have been thoroughly recrystallized and reconstituted. However, some work in the petrofabrics of moderately deformed sedimentary rocks has been done by Ernst Cloos and his students²⁷ and deserves consideration. The rocks studied are in the folded belt of the Appalachians, but in the absence of petrographic analysis would not impress the observer as having suffered much internal change. However, study of oolites in the limestones and quartz grains in the quartzites indicates that much flowage has taken place.

20. *Laboratory experiments.*—The purpose of laboratory experiments is indicated as follows by the Research Council sub-committee.²⁸

In many problems formal analysis from known data, even though allowing of a unique solution, would involve one in hopeless mathematical difficulties. In such instances we may resort to another physical tool—the theory of dimensions—which tells us how to build a model that will perform like the original and will consequently enable us to get an answer experimentally which might be unobtainable otherwise. Although precision of data in such cases is always desirable, it is frequently irrelevant whether the data are correct to two significant figures or to seven.

The Research Council sub-committee outlines the following classes of subjects as deserving study:²⁹

1. Measurement in the laboratory of the elastic, plastic, and viscous properties of rocks and minerals with temperature, time, presence of volatiles, and stress as independent variables
2. Experimentation by means of dimensionally correct scale models of geologic features. (The methods of experiment being developed in soil mechanics contain many features of use in geological experimentation)
3. Study of stress distribution in geologic features by application of photoelastic technique to dimensionally correct scale models. . . .
4. Experimental investigation of orientation of particles due to plastic deformation
5. Experimental investigation of fracture, cleavage, and faulting. One very important problem here is the orientation of the systems of fracture and cleavage
6. Petrofabric analysis of artificially deformed rocks. . . .
7. Study of the flow of salt

The status of experimental work in tectonics is summarized as follows by Hubbert:³⁰

²⁷ Ernst Cloos, "Distortion of Stratigraphic Thicknesses Due to Folding," *Proc. Nat. Acad. Sci.*, Vol. 28 (1942), pp. 401-07.

R. E. Fellows, "Recrystallization and Flowage in Appalachian Quartzites," *Bull. Geol. Soc. America*, Vol. 54 (1943), pp. 1399-1432.

Ernst Cloos, "Lineation; a Critical Review and Annotated Bibliography," *Geol. Soc. America Mem.* 138 (1946), pp. 43-45.

²⁸ M. K. Hubbert, W. H. Bucher, D. T. Griggs, and A. Nadai, *op. cit.*, . . 17.

²⁹ *Ibid.*, p. 19.

³⁰ M. K. Hubbert, "Strength of the Earth," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 29 (1945), pp. 1651-53.

See also, ———, "Theory of Scale Models as Applied to the Study of Geologic Structures," *Bull. Geol. Soc. America*, Vol. 48 (1937), pp. 1459-1519.

For more than a century and a quarter attempts have been made to simulate the formation of mountains and other tectonic structures by means of small scale models. In the preponderance of such cases the materials used have consisted of hard waxes, stiff clays, partially cemented sands, plaster of paris, and similar substances, and the results have been indifferent at best. Typical and among the better known of such experiments are those made by Bailey Willis in his classical study of the folding of the Appalachian Mountains. Willis constructed models of about a meter in length representing the unfolded strata of the Appalachian geosyncline. These were compressed longitudinally into structures simulating those of the Appalachian Mountains. . . .

If one of Willis' models were to be regarded as representing an Appalachian section of about 100 kilometers in length the overburden used would be equivalent to 150 to 300 kilometers of rock. Even then the more rigid strata broke into discrete slabs and open cavities appeared. The Appalachians had no such overburden, but were held down solely by their own weight, yet the folding in the most rigid strata was continuous and no open cavities were formed. Hence it must be concluded that the rocks of the Appalachians in respect to their environment were much weaker than the materials used by Willis, or conversely, that Willis' materials were much too strong to represent the Appalachian Mountains.

As remarked before, the materials used and the results obtained by Willis are typical of most of the model experiments upon geologic structures which have so far been performed. Notable exceptions occur in the cases of some experiments performed by Koenigsberger and Morath about 1912, and in the later 1920's by Hans Cloos. . . . Cloos reasoned simply that if an original geologic feature were composed of rocks strong enough to support a column 10 to 20 kilometers high, a model with a length reduction of 1/50,000 should be capable of supporting a column 1/50,000 as high, or 20 to 40 centimeters. On this basis he then selected soft, half-liquid clay as his experimental material. With this he has been able to obtain some of the most accurate duplications of a wide variety of geologic structures which have so far been achieved.

Better known to the oil fraternity are the experiments of Nettleton wherein salt dome formation has been represented by means of viscous fluids of contrasting densities. While not accurate in all details, these experiments of Nettleton afforded a far more convincing demonstration of the mechanics of salt-dome formation than any previous attempts.

Recently a model experiment has been described by Griggs for the demonstration of the hypothesis of mountain folding by deep-seated convection. The model parameters of that experiment were determined in accordance with the theory as developed by the present writer (Hubbert). The results were in remarkable accord with the major tectonic features of many existing mountain ranges.

This discussion indicates that the whole field of experimental work in tectonics needs reconsideration in the light of new concepts, and that many experiments that have been made in the past should be done over, using much weaker materials.

In regard to experimental work, Ernst Cloos writes:

My brother (Hans Cloos) has made many domes and the experiment is rather simple to repeat. It may well be that such an artificial dome is not exactly a natural one, but the experiments are very suggestive and we have learned a lot by performing them. One can either approach a definite problem in the field and experiment with the problem in mind, or one can perform experiments and verify the findings in the field. Either approach is fruitful and if there would be a call for it, I would be most willing to teach others what to do. I have at present little time to work in that direction systematically, but have for teaching purposes frequently dusted off my equipment and used it. . . . My equipment is now good and could easily improve with very little cost. The cost of that sort of experimental work is almost negligible.

James Gilluly writes:

We are now in the process of organizing an institute of geophysics here at U.C.L.A. and when that is done, I am going to try to get the help of competent geophysicists in some model work. I believe there is a considerable contribution possible there, but I certainly don't know enough geophysics to do it myself. On the other hand, very few geophysicists know enough geology to do it by themselves. Maybe a team could get somewhere.

L. L. Nettleton writes:

The experimental work which I have done in the past has been limited to the fluid salt dome models and has been published in the *Bull. Amer. Assoc. Petrol. Geol.* (Sept., 1934 and Jan., 1943). More recently, I have been doing some preliminary experiments designed to investigate faulting with special reference to that which occurs around salt domes and the rather common situation of having faults in the sediments above domes, for which the downthrown side is towards the dome, rather than away from it, as might be expected from simple considerations. To the extent that the work may be

successful in showing the mechanics by which such faults are formed (a stage which has not yet been reached), this work might be considered as an attempt to solve a specific practical problem. . . . However, it is hoped that along with it, much more general and theoretical questions may be considered.

A primary factor in all of this work has been to keep in mind as much as possible the dimensional factors involved in these model studies along the lines pointed out by Hubbert. Incidentally, I should remark that the work which I have done is only as a rather occasional sideline of my primary duties, and therefore has had rather irregular and intermittent attention on my part.

The results of the recent experimental work noted above were presented by Nettleton at the 1946 meeting of the American Geophysical Union. In discussing the use of motion pictures in geological education, Nettleton suggests the desirability of having:

. . . a short film made of the Cloos clay models. I understand that such a film was made in Germany but is not available here. It is my own feeling that a few hundred dollars spent to make such a film or to acquire it, if already made, and then making this film available for loan to local geological societies and schools would so dramatize many features of structural geology that it would have a real influence on thinking along these lines.

T. A. Link writes:

If I were teaching a course in structural geology I would devote considerable time to laboratory studies for all the students wherein they would be required to do some of the more elementary experiments. I am firmly convinced that any geologist who has devoted some time to such experimental work, no matter how simple, has gained a considerable advantage over those who have not. . . . However, for advanced structural research, something more elaborate than that must be considered.

The establishment of a laboratory in which there is available a work or machine shop, high and low temperatures and pressures, compressed air, power, etc., is my idea of an ideal setup for serious experimental research in structural geology and tectonics. . . . I have always had a hankering to be able to go into a first-class laboratory where everything would be available, where things could be built with precision tools and experiments were conducted under controlled conditions. This applies not only to the apparatus itself but to the materials used.

There are so many problems of regional structural study which might be studied in the laboratory from which one or two ideas might be forthcoming. We now have in our universities and for industry, laboratories for Chemistry, Physics, Geophysics, etc. fully equipped, but I know of no first-class laboratory for structural and tectonic geology. (There may be some, but I am not aware of it). Such laboratories would naturally have to be manned with skillful technicians, guided by geologists with ideas and, above all, with enthusiasm.

Mrs. E. B. Knopf²¹ proposes a study of experimentally deformed rocks, starting first with single crystals, and proceeding to monomineral rocks, and finally to polymineral rocks. Such a study is concerned more with the minutiae of rock deformation than with the larger features, but would certainly influence thinking in many phases of tectonics.

The sub-committee on tectonics feels that experimental work on the subject is of fundamental importance, and would like to see specific projects formulated and proposed in this type of work.

ACCESSORY ITEMS

A number of other items deserve consideration which, while not research, are useful tools and aids to the research worker.

21. *Definitions.*—The terminology of structural features, although discussed at length in many text books and the subject of decisions by many committees, continues to be a matter of debate in geological periodicals. This is partly due to loose thinking on the part of geologists, and the difficulty of a geologist in mastering voluminous terminology in more than a few specialties. It is also because terminology is inevitably linked to geological concepts, and as these concepts change, or new concepts arise, changes and additions in terminology are necessary. Probably it will be necessary from time to time to systematize our terminology by the further work of committees.

²¹ E. B. Knopf, "Postwar Study of Experimentally Deformed Rocks," *Trans. Amer. Geophys. Union*, Vol. 26, (1945), pp. 303-04.

Ralph L. Miller writes:

A committee on definitions seems to me highly desirable to set up standards of usage for structural terms. One need only point to the extreme confusion that now exists in the literature on usage of the terms reverse fault, thrust fault, and overthrust fault to show the desirability of standardizing and publicizing structural nomenclature.

Another type of terminology is that of the specific names of individual structural features. No one would probably wish to standardize these as rigidly as stratigraphic or zoologic names, but in some places confusion has arisen because different names have been used for the same feature. This became apparent in the editing of the Tectonic Map of the United States, and for this many arbitrary decisions had to be made, some of which will probably require revision. Supervision of the standardization of names for specific structural features could be well undertaken by the respective State Surveys.

22. *Base maps.*—Several geologists interested in tectonics have expressed the wish for more adequate base maps on scales of 1:1,000,000 and 1:500,000 for use in plotting information. A similar wish on the part of geophysicists has been expressed by M. K. Hubbert, and it is no doubt shared by geologists and geographers working in other fields.

Base maps on a scale of 1:500,000 by the United States Geological Survey are available for all the states, but these do not show relief features and if the plotting crosses state boundaries several maps must be cut out and fitted together. Some other system of maps, with lines of division along meridians and parallels, would be more satisfactory for many purposes.

A useful series, when completed, will be the sheets of the International Map of the World, on a scale of 1:1,000,000. Of the 70 sheets required to cover the United States, five have so far been published by the United States Geological Survey, and six more are reported to be nearly ready for publication. The writer has found the similar series—the Millionth Map of Hispanic America—to be very useful for plotting tectonic and other geologic information. Tracing material is laid over the sheet; orientation is provided by the drainage, towns, relief, and coordinates; and the data are marked on the overlay.

A similarly useful series are the air navigation charts of the United States published by the United States Coast and Geodetic Survey, one group on 1:1,000,000, and another on 1:500,000. The copies for general distribution are overprinted with air navigational data, of no value for the present purpose, but copies without the overprint are available on request. The maps show enough relief, drainage, and cultural features to guide the user without being cluttered, and are divided into 15-minute coordinates that are very useful for plotting.

23. *Bibliographies and abstracts.*—Ernst Cloos contributes the following discussion.

Bibliographies and abstracts are extremely useful and I would like to add that the systematic review of a problem and assemblage of all the literature plus a critical discussion can do a great deal to inform the interested geologist and save him immense amounts of time. I have just now in print a critical discussion and bibliography on lineation.²² . . . I have 375 literature references, all annotated and ranging from 1832 to 1943. I hope that such a review and compilation will be handy for many who cannot go into it as I did and don't need to if my work is sufficiently full and accurate. A similar bibliography on faults has been planned, but I have not gotten to it yet. . . .

Such compilations are drudgery but extremely useful if done well and in years to come it will be absolutely impossible for the student that begins today to be fully informed on the literature because the literature grows at such a rate that even those who have a head start, like we ourselves, can't keep up with it. The field I can keep up with grows smaller and smaller, simply because I can't keep up with all I started with. I therefore feel that some of the older men that are qualified to do so should contribute about a year of their time to one such compilation which will then be a handbook, not necessarily containing all the information, but certainly containing all the literature references, and if at all possible, annotated so that it becomes possible to see what the author was driving at . . . and what his conclusion is.

²² Ernst Cloos, "Lineation; a Critical Review and Annotated Bibliography," *Geol. Soc. America Mem.* 18 (1946).

REVIEWS AND NEW PUBLICATIONS

* Subjects indicated by asterisk are in the Association library, and are available, for loan, to members and associates.

PETROLEUM PRODUCTION ENGINEERING, BY LESTER CHARLES UREN

REVIEW BY HARRY H. POWER¹

Austin, Texas

**Petroleum Production Engineering—Oil Field Development*. New Third Edition (1946). By Lester Charles Uren. 764 pp., 321 figs. Cloth. 6×9 inches. McGraw-Hill Book Company, Inc., New York. Price, \$7.00.

The new third edition of *Petroleum Production Engineering* by Lester Charles Uren, professor of petroleum engineering at the University of California, presents a complete, systematic, and well balanced treatment of petroleum production engineering through all the phases of oil-field development and up to the point at which the wells are ready to produce. Most of the material of prior editions has been re-written by the author and many new features covering recent developments in the technology of oil-field practice have been added.

Beginning with chapters devoted to the properties and occurrence of petroleum in nature, petroleum exploration methods, and principles of oil-field development, the author discusses in detail the operations of drilling and equipping wells. Succeeding chapters are devoted to the occurrence and behavior of water in sedimentary strata, the identification of water-yielding formations in drilling, and methods of excluding water from wells. Fishing tools and methods of fishing, well-completion methods, well records, logging methods, surveys, and inspection of formation samples are the concluding chapters of this book.

In view of the increased attention paid to problems in reservoir engineering, the two concluding chapters are of particular interest currently. An excellent summary of modern correlation methods, including geological, electrical, radioactive, geochemical, temperature, drilling-time, and caliper logging is presented for ready reference of student or the busy engineer and geologist in industry who may wish to review these subjects in an orderly manner. Likewise, the final chapter gives a well organized discussion of the various laboratory methods for the inspection and testing of formation samples. The methods specifically discussed are: extraction, identification, and determination of fluid content of core samples; porosity and permeability determinations; size distribution of granular components of formation samples; concentration and identification of microfossils in formation samples; and methods of displaying results of core inspection and analysis.

The unusual task presented in culling out of the voluminous petroleum literature of today those features of practical interest to the student, practicing engineer, geologist, or executive, has been pursued by the author for many years. Few readers grasp the enormity of this task. Reference to the most excellent bibliography at the end of each chapter (which alone is worth the price of the book) should convince anyone, on sober reflection, that Charles Lester Uren, through the years, has performed a service that the educational institutions and industry alike should give full and well deserved recognition.

¹ Professor of petroleum engineering, the University of Texas. Review received, October 21, 1946.

GEOLOGÍA DE BOLIVIA, BY F. AHLFELD

REVIEW BY NORMAN D. NEWELL¹

New York, N. Y.

"Geología de Bolivia," by Federico Ahlfeld, Instituto del Museo de la Plata. *Revista del Museo de la Plata*, t. 3, Geología, No. 19 (May 18, 1946). 370 pp., 115 figs., with colored geological map of Bolivia, scale 1:212,000.

The appearance of this important memoir will be enthusiastically hailed by all students of Andean geology. The "Geología de Bolivia" is Ahlfeld's *magnum opus*, for which he has been gathering data ever since he first went to Bolivia in 1923. In 1935 he became chief geologist for the Dirección General de Minas y Petróleo, an important post which he has occupied until the present year.

With admirable courage and determination he has labored unflinchingly and almost alone, while sorely handicapped by what most European and American geologists would regard as the most limited funds and inadequate working facilities. It is with regret that we learn that Ahlfeld's work in Bolivia comes to a close with the publication of his book.

After paying appropriate respects to the great pioneers of Bolivian geology, d'Orbigny, Steinmann, Kozłowski, and many others, Ahlfeld indicates, in the first chapter, the extent of his own travels and observations in Bolivia, which certainly exceed those of any other geologist.

In subsequent chapters the author discusses the main geologic regions of Bolivia: the Oriente, or eastern lowlands, the sub-Andean area, the Eastern and Central Cordilleras, and the high plateau, together with the Western Cordillera. Chapters are devoted to the Quaternary geology, orogenesis, geologic history, mineral deposits, and seismology.

A regional geological map of the Bolivian Andes, covering much of the Republic, accompanies the memoir. The author wisely leaves blank several large areas as "*inexplorado*."

The stratigraphic column includes Cambrian, Ordovician, Gotlandian (Silurian), Devonian, Permo-Carboniferous (Lower Permian), continental Permian, Cretaceous (mainly continental), and continental Tertiary and Quaternary. Twenty different divisions are indicated on the map, as are many great overthrusts and normal faults. This map, as Ahlfeld clearly states, represents a compilation of all available data, collated and revised in terms of his own observations. No claim is made that it is the "first" geological map of the country, since that distinction belongs to a map published over a century ago by d'Orbigny. A second map by Leonardo Olmos, based largely on the early map appeared in 1912.

In an admirably restrained statement (footnote, p. 352) Dr. Ahlfeld notes that a geological map of Bolivia published in 1944, by V. Oppenheim, was based directly on the manuscripts and preliminary maps made available to him, in good faith, during a visit to La Paz, in 1942. The reviewer learned the source of Oppenheim's data directly from that author, who felt no need for hesitancy in publishing the map without authorization, since he had modified it in some respects, adding original data of his own. The Geological Society of America received a manuscript copy of Ahlfeld's map, in essentially its final form, as early as 1943.

The *Geología de Bolivia* is so packed with data, many of them herein published for the first time, that an adequate digest will not be attempted in this review. Two salient facts are of interest to the reviewer, however. It is evident that the histories of the Eastern and Western Cordilleras were quite different, as is also the case in southern Peru. All of the Paleozoic rocks in Bolivia lie in the Eastern ranges, whereas the vast volcanism of the region essentially is confined to the Western Cordillera and to the Altiplano.

¹ Curator of historical geology and fossil invertebrates, American Museum of Natural History; professor of geology, Columbia University. Review received, October 21, 1946.

The Corocoro group, of probable early-medial Tertiary age, occupies the southwestern part of the Altiplano. In southern Peru these beds (Puno group) overlap early Cenomanian marine beds, resting locally on the Devonian. These Tertiary deposits are enormously thick continental redbeds, containing much coarse volcanic material, clearly indicating orogeny, probably Laramide, followed by rapid subsidence and volcanism. Paralleling the Corocoro group in the near-by area of the Eastern Cordillera of Bolivia, is the Puca group. Over great areas the Puca group is gradational from Senonian marine horizons upward through the early Tertiary, and the Mesozoic-Cenozoic boundary can be recognized only with considerable difficulty. One is led to conclude that Laramide folding was confined to the Western Cordillera and the Altiplano, whereas sedimentation in the Eastern Cordillera was interrupted, if at all, only by epeirogeny.

After deposition of the Corocoro group the region experienced the principal folding of the Andes. The Corocoro beds contain a fossil flora, and since they are the youngest tightly folded deposits in northern Bolivia their age assignment figures importantly in dating the last orogeny.

Ahlfeld believes that a Pliocene age for the Corocoro beds, as specified by Berry, gives too recent a date for the folding of the Andes and, consequently, he is disposed to conclude that the fossil flora and the folding of the region is more probably Miocene or perhaps even older, a view which was held by Steinmann and by Kozłowski. The reviewer is inclined to endorse this general conclusion, perhaps following slightly different logic. Fossil floras of the late Tertiary are commonly believed to reflect environmental facies more than absolute age, so that precise dating of sediments by means of these floras is very difficult. An extremely important fact, which should have been given greater emphasis by Ahlfeld, is that the folded Corocoro group is truncated by the upland peneplain described by Bowman, McLaughlin, and others. The great volcanic cover of the Western Cordillera rests nearly horizontally on the old erosion surface. The volcanics contain interbedded Pliocene (or Miocene?) fossils (Mauri formation) in Bolivia. Miocene (?) and Pliocene marine faunas near Icla, on the Peruvian coast appear to rest on an old erosion surface, which may correspond with the great upland peneplain. It seems unlikely that the Pliocene alone would suffice for the folding of the Andes and their subsequent peneplanation, followed by deposition of a considerable part of the later volcanics. To the reviewer it seems more likely that the orogenic cycle was completed no later than the Miocene, and possibly was begun even earlier.

Ahlfeld's book is well illustrated by numerous original sections, maps, and sketches, and by many of the author's excellent photographs, for which he is justly noted.

Without intent to detract from the great value of this work it is pertinent to note that numerous typographical errors occur here and there throughout the book. The halftone cuts, which appear to be of high quality, would have resulted much better on a good coated paper.

Ahlfeld's own estimation of his work indicates an appreciation of its limitations.

I beg of all my colleagues that they keep in mind, while criticizing this work, that it endeavors, for the first time, to touch on the collective geological problems of Bolivia. It is realized that this attempt will present many shortcomings. Likewise, it must be said that the geological map . . . will be subject to many corrections in the future. It was my intention to offer, by means of the book and the map, a review of all our present knowledge over the geology of Bolivia, based on existing publications, and on my own new observations. It is my chief hope that they serve as a base for future geological investigations in Bolivia.

RECENT PUBLICATIONS

ALABAMA

"Geologic Map of Tuscaloosa and Cottondale Quadrangles, Alabama, Showing Areal Geology and Structure of Upper Cretaceous Formations," by L. C. Conant, D. H. Eargle, W. H. Monroe, and J. H. Morris. *U. S. Geol. Survey Prelim. Map 37*, Oil and Gas Investig. Ser. (October, 1946). Map, scale 1 inch equals 1 mile, covers 500 square miles. Geology, subsurface structure contours on Paleozoic rocks and on Cottondale, Eoline, and Coker formations of Tuscaloosa group; also, text and detailed graphic section of Tuscaloosa. For sale by Director, Geological Survey, Washington 25, D. C. Price, \$c.55.

APPALACHIANS

*"Appalachian Drainage and the Highland Border Sediments of the Newark Series," by C. W. Carlston. *Bull. Geol. Soc. America*, Vol. 57, No. 11 (New York, November, 1946), pp. 997-1032; 3 pls., 1 index map.

ARGENTINA

*"Contribución al Conocimiento Geológico de la Precordillera Sanjuanino-Mendocina" (Contribution to geological knowledge of the pre-Cordillera of San Juan and Mendoza provinces), Part 5, by Osvaldo Bracacchini. *Bol. Inform. Petroleras*, Vol. 23, No. 263 (Buenos Aires, July, 1946), pp. 22-35; 4 cross sections, 4 photographs. In Spanish. (Parts 1-4 published in Nos. 258, 260, 261, and 262 of *Bol. Inform. Petroleras*.)

CALIFORNIA

*"Classification of Oil Discoveries and Fields," *Anonymous. Petroleum World*, Vol. 43, No. 11 (Los Angeles, November, 1946), pp. 72-75. Report of Classification Committee (Frank S. Parker, chairman) of Pacific Section, A.A.P.G. Includes detailed schedule of California field and pool names prepared by joint committee of Pacific Section, A.A.P.G., and Conservation Committee of California Oil Producers.

*"Submarine Photography off the California Coast," by F. P. Shepard and K. O. Emery. *Jour. Geol.*, Vol. 54, No. 5 (Chicago, September, 1946), pp. 306-21; 1 index map, 1 bottom-sediment chart, 28 photographs.

COLORADO

"Subsurface Maps of the Rangely Anticline, Rio Blanco County, Colorado," by N. W. Bass. *U. S. Geol. Survey Prelim. Map 67*, Oil and Gas Investig. Ser. (October, 1946). Single sheet, 32 X 44 inches. Map of the Rangely oil field shows structure contours drawn on top of the oil-producing Weber sandstone; other maps show the thickness of the redbeds above the Weber sandstone, and the thickness of all the rocks between the Dakota sandstone and the Weber. Diagrams and explanatory text included. Mail orders should be sent to the Director, Geological Survey, Washington 25, D. C. Price, \$c.25.

*"Rangely Faults—Good and Bad," by S. M. Newton. *Oil Reporter*, Vol. 3, No. 18 (Denver, October 22, 1946), pp. 8-11, 27; illus.

EUROPE

*"The Geological Structure of East Poland and West Russia: A Summary of Recent Discoveries," by Zbigniew Sujkowski. *Quar. Jour. Geol. Soc. London*, Vol. 102, Pt. 2, No. 406 (London, July 31, 1946), pp. 189-201; 2 figs., 2 tables, 1 geologic map, list of references.

*"The Natural Steam at Larderello, Italy," by W. D. Keller and Adriano Valduga. *Jour. Geol.*, Vol. 54, No. 5 (Chicago, September, 1946), pp. 327-34; 3 tables, 4 figs. Description and report of utilization of emanations delivered through fractures from probable batholith freezing beneath.

GENERAL

*"Trimetrogon Aerial Photography," by Ralph W. Disney. *Oil and Gas Jour.*, Vol. 45, No. 24 (Tulsa, October 19, 1946), pp. 113-15; 4 figs., 3 photographs. Description of a wartime development of the science of photogrammetry, credited to the Alaskan Branch, U. S. Geological Survey.

*"Radioactivity Well Logs—Interpretation and Application. Part 1, Gamma Ray Curves; Part 2, Neutron Curves; Part 3, Combination Radioactivity Logs," by V. J. Mercier. *Oil Weekly*, Vol. 123, No. 7 (Houston, October 14, 1946), pp. 56-60; 7 figs.

**Ibid.* "Part 4, Correlation with Other Type Logs; Part 5, General Considerations; Part 6, Conclusion," by V. J. Mercier, Vol. 123, No. 8 (October 21, 1946), pp. 41-46; 7 figs., references.

*"Temperature Well Logging. Part 1, Heat Conduction," by Hubert Guyod. *Ibid.*, pp. 35-39; 9 figs., 2 tables.

**Ibid.* "Part 2, Salt Intrusions," Vol. 123, No. 9 (October 28, 1946), pp. 33-42; 14 figs.

*"Influence of Clay Content on Water Conductivity of Oil Sands," by T. F. Bates, R. M. Gruver, and S. T. Yuster. *Oil Weekly*, Vol. 123, No. 8 (October 21, 1946), pp. 49-50; 5 figs. Results of a study of the clay minerals associated with the Bradford oil sand, employing (1) differential thermal analysis, (2) X-ray spectrometer, and (3) the electron microscope.

*"The Performance of Bottom Water-Drive Reservoirs," by Morris Muskat. *Petrol. Tech.*, Vol. 9, No. 5 (New York, September, 1946). 31 pp., 20 figs. *Amer. Inst. Min. Met. Eng. Tech. Pub.* 2060.

*"A New Well-Completion Technique," by T. S. West. *Petrol. Tech.*, Vol. 9, No. 5 (New York, September, 1946). 17 pp., 9 figs., 1 table. *Amer. Inst. Min. Met. Eng. Tech. Pub.* 2094.

*"Grado de exactitud de los métodos de exploración para petróleo" (Accuracy of Methods of Petroleum Exploration), by Juan J. Zunino. *Bol. Inform. Petroleras*, Vol. 23, No. 263 (Buenos Aires, July, 1946), pp. 15-21; illus. In Spanish.

*"Petroleum Appraisal and Financing," by E. M. Reed. *Oil Weekly*, Vol. 123, No. 8 (Houston, October 21, 1946), pp. 57-61.

*"Secondary Recovery Research of the Bureau of Mines," by D. B. Taliaferro. *Independent Petrol. Assoc. Amer. Monthly*, Vol. 17, No. 6 (Tulsa, October, 1946), pp. 15-18; 4 photographs.

*"The Domestic Oil Producers Interest in Oil Shale," by Harry K. Savage. *Ibid.*, pp. 32-36; 2 tables, 1 graph, 1 photograph.

*"Possibilities and Problems of Drilling beyond the Continental Shelf," by Henry Emmett Gross. *Petrol. Engineer*, Vol. 18, No. 1 (Dallas, October, 1946), pp. 186-92; 6 figs. Probable locations of deposits are discussed, as well as a plausible method of drilling and its limitations.

*"Stratigraphical Problems in the Coal Measures of Europe and North America," by Arthur Elijah Trueman. *Quar. Jour. Geol. Soc. London*, Vol. 102, Pt. 2, No. 406 (London, July 31, 1946), pp. 49-93; 10 figs., 1 correlation chart, references. Anniversary address of the president of the Geological Society of London.

*"Volcanic Heat," by J. Verhoogen. *Amer. Jour. Sci.*, Vol. 244, No. 11 (New Haven, Connecticut, November, 1946), pp. 745-72.

Principes de géologie, by P. Fourmarier. 2d ed., revised and enlarged. 1212 pp. (2 vols.); 675 pls., figs. Published by Masson & Cie; H. Vaillant-Carmanne S. A. (Paris and Liège, 1944). Reviewed by Richard Foster Flint in *Amer. Jour. Sci.*, Vol. 244, No. 11 (New Haven, Connecticut, November, 1946).

*"Temperature Well Logging. Part 3, Temperature Distribution," by Hubert Guyod. *Oil Weekly*, Vol. 123, No. 10 (Houston, November 4, 1946), pp. 32-39; 17 figs.

**Ibid.* "Part 4, Wells in Thermal Equilibrium." Vol. 123, No. 11 (November 11, 1946), pp. 50-53; 8 figs.

*"Acidizing Increases Water Intake Rates," by R. J. Pfister. *Oil Weekly*, Vol. 123, No. 11 (Houston, November 11, 1946), pp. 70-74; 4 figs., 1 table.

*"Clay Research and Oil Development Problems," by J. C. Griffiths. *Ibid.*, pp. 82-89; 2 tables.

*"Oil Production by Water. Part 1, Basic Elements and Definitions," by Park J. Jones. *Oil and Gas Jour.*, Vol. 45, No. 26 (Tulsa, November 2, 1946), pp. 64-65.

**Ibid.* "Part 2, Dry-Oil Recovery for Uniform Distribution of Pay." Vol. 45, No. 27 (November 9), pp. 88-90; 4 figs.

**Ibid.* "Part 3, Oil Ahead of Water." Vol. 45, No. 28 (November 16), pp. 314-16; 6 figs.

*"A Review of Geophysical Methods, Devices, and Procedures," by C. H. Dresbach and Paul Weaver. *Oil and Gas Jour.*, Vol. 45, No. 26 (Tulsa, November 2, 1946), pp. 79-81.

"Oil and Gas Fields of the United States," by Paul Averitt, Jane Hanna, and Jane T. Carlton. *U. S. Geol. Survey* (November, 1946). 2 sheets, each 41 X 51 inches. Scale, approximately 1 inch equals 40 miles. Oil and gas fields developed to March 1, 1946, major refining centers, and major oil, gas, and petroleum products pipe lines. For sale by Director, Geological Survey, Washington 25, D. C.

GEORGIA

*"Geology and Ground-Water Resources of the Coastal Plain of East-Central Georgia," by Philip E. LaMoreaux. *Georgia Geol. Survey Bull.* 52 (Atlanta, 1946). 173 pp., 2 pls., 21 figs.

ILLINOIS

*"Fresh- and Brackish-Water Vertebrate-Bearing Deposits of the Pennsylvanian of Illinois," by Everett Claire Olson. *Jour. Geol.*, Vol. 54, No. 5 (Chicago, September, 1946), pp. 281-305; 3 figs.

INDIANA

*"The Geology of Cataract Falls, Owen County, Indiana," by Clyde A. Malott. *Jour. Geol.*, Vol. 54, No. 5 (Chicago, September, 1946), pp. 322-26; 2 figs.

KANSAS

*"Geology and Ground-Water Resources of Grant, Haskell, and Stevens Counties, Kansas," by Thad G. McLaughlin. *State Geol. Survey Kansas Bull.* 61 (Lawrence, July, 1946). 221 pp., 12 pls., 18 figs., 20 tables.

*"Glimpses from Resource-Full Kansas." 40-page, illustrated booklet published by the State Geol. Survey of Kansas, 1946. Contains brief stories about the scenery, mineral fuels, deposits of industrial minerals, rocks, fossils, and well-water supplies of Kansas.

MONTANA

*"Origin and Mechanics of the Thrust Faults Adjacent to the Bearpaw Mountains, Montana," by Frank Reeves. *Bull. Geol. Soc. America*, Vol. 57, No. 11 (New York, November, 1946), pp. 1033-48; 1 pl., 6 figs.

NEW JERSEY

*"Artificial Recharge of Productive Groundwater Aquifers in New Jersey," by Henry C. Barksdale and George D. DeBuchananne. *Econ. Geology*, Vol. 41, No. 7 (Urbana, Illinois, November, 1946), pp. 726-37; 3 figs.

NEW MEXICO

*"McCarty's Basalt Flow, Valencia County, New Mexico," by R. L. Nichols. *Bull. Geol. Soc. America*, Vol. 57, No. 11 (New York, November, 1946), pp. 1049-86; 8 pls., 15 figs.

OHIO

"Map of the Berea Sand of Northern Ohio," by J. F. Pepper, D. F. Demarest, W. DeWitt, Jr., R. D. Holt, and C. W. Merrels 2d. *U. S. Geol. Survey Prelim. Map 39*, Oil and Gas Investig. Ser. (October, 1946). Map on Sheet 1 covers 8,000 square miles, and shows productive oil and gas pools. Sheet 2 includes maps, diagrams, cross sections, and text describing Berea sand. For sale by Director, Geological Survey, Washington 25, D. C. Price, \$0.65.

PACIFIC REGION

*"Drowned Ancient Islands of the Pacific Basin," by H. H. Hess. *Amer. Jour. Sci.*, Vol. 244, No. 11 (New Haven, Connecticut, November, 1946), pp. 772-92; 8 figs.

*"Lithification of Pleistocene Clay at Kahuku Point, Oahu," by Randolph W. Chapman. *Bull. Geol. Soc. America*, Vol. 57, No. 11 (New York, November, 1946), pp. 985-96; 2 pls., 2 figs.

SOUTH AMERICA

"Reservas Petroliferas de Sud America" (Petroleum Reserves of South America), by Victor Oppenheim. *Boletín de Minas y Petróleo*, Vol. 16, No. 9 (Mexico, D. F., September, 1946), pp. 43-44. Taken from *Boletín del Instituto Sudamericano de Petróleo*, Montevideo, Uruguay. In Spanish.

TEXAS

*"West Texas Modern Refraction Seismic Exploration," by Sidon Harris. *Oil Weekly*, Vol. 123, No. 7 (Houston, October 14, 1946), pp. 52-55; 4 figs. Modern techniques being used on the Edwards Plateau area of West Texas.

*"South Texas Giant," by Charles J. Deegan and Neil Williams. *Oil and Gas Jour.*, Vol. 45, No. 27 (Tulsa, November 9, 1946), pp. 60-64; 5 figs, including type electrical logs and subsurface structural map of line of oil fields along Vicksburg flexure in South Texas.

WEST INDIES, MEXICO, CENTRAL AND SOUTH AMERICA

"Magnetic Observations in the American Republics, 1941-44," *U. S. Coast and Geodetic Survey Serial 677* (October, 1946). Report prepared in cooperation with U. S. Department of State and governments of various American Republics. Illustrations include maps showing distribution of stations, diagrams of daily variation curves, and reproductions of photographs showing personnel, instrumental equipment, observations, and station sites. For sale by Superintendent of Documents, Government Printing Office, Washington 25, D. C. Price, \$1.25.

THE ASSOCIATION ROUND TABLE

ASSOCIATION COMMITTEES

EXECUTIVE COMMITTEE

EARL B. NOBLE, *chairman*, Union Oil Company of California, Los Angeles, California
EDWARD A. KOESTER, *secretary*, Darby & Bothwell, Wichita, Kansas
MONROE G. CHENEY, Anzac Oil Corporation, Coleman, Texas
D. PERRY OLCOTT, Humble Oil and Refining Company, Houston, Texas
GAYLE SCOTT, Texas Christian University, Fort Worth, Texas

REPRESENTATIVE ON DIVISION OF GEOLOGY AND GEOGRAPHY
NATIONAL RESEARCH COUNCIL: PHILIP B. KING (1949)

REPRESENTATIVES ON COUNCIL OF AMERICAN ASSOCIATION
FOR THE ADVANCEMENT OF SCIENCE

CARROLL E. DOBBIN

ROBERT J. RIGGS

REPRESENTATIVES ON COMMISSION ON CLASSIFICATION AND
NOMENCLATURE OF ROCK UNITS

M. G. CHENEY (1947), *chairman*

JOHN G. BARTRAM (1948)

WAYNE V. JONES (1949)

STANDING COMMITTEES

FINANCE COMMITTEE

FRANK R. CLARK (1947), *chairman*

JOSEPH E. POGUE (1948)

JOHN S. IVY (1949)

TRUSTEES OF REVOLVING PUBLICATION FUND

W. D. KLEINPELL (1947), *chairman*

W. B. WILSON (1948)

WILLIAM B. HEROY (1949)

TRUSTEES OF RESEARCH FUND

E. O. MARKHAM (1947), *chairman*

T. S. HARRISON (1948)

ROBERT W. CLARK (1949)

BUSINESS COMMITTEE

C. L. MOODY (1947), *chairman*, Ohio Oil Company, Shreveport, Louisiana

ROY M. BARNES (1947), *co-chairman*, Continental Oil Company, Los Angeles, California

A. P. ALLISON (1947)

WARREN D. ANDERSON (1948)

E. J. BALTRUSAITIS (1947)

FRANK W. BELL (1948)

OLIN G. BELL (1948)

JOSEPH L. BORDEN (1947)

MAX BORNHAUSER (1947)

IRA H. BRINKERHOFF (1948)

MONROE G. CHENEY (1947)

H. E. CHRISTENSEN (1948)

FRANK R. CLARK (1948)

CARLE H. DANE (1948)

ADOLPH DOVRE (1947)

ROLLIN ECKIS (1947)

STANLEY G. ELDER (1948)

ROBERT M. ENGLISH (1947)

GLENN C. FERGUSON (1947)

GEORGE R. GIBSON (1947)

WESLEY G. GISH (1948)

W. DOW HAMM (1948)

GLENN D. HAWKINS (1947)

L. W. HENRY (1947)

J. S. HUDNALL (1947)

EDWIN H. HUNT (1947)

JOHN W. INKSTER (1947)

ROBERT L. KIDD (1948)

EDWARD A. KOESTER (1947)

CLAUDE E. LEACH (1948)

PAUL B. LEAVENWORTH (1947)

LYNN K. LEE (1947)

SHIRLEY L. MASON (1948)

GAIL F. MOULTON (1947)

JERRY B. NEWBY (1947)

EARL B. NOBLE (1948)

D. PERRY OLCOTT (1947)

ELISHA A. PASCHAL (1948)

F. W. ROLSHAUSEN (1947)

J. J. RUSSELL, JR. (1948)

GAYLE SCOTT (1947)

ROBERT L. SIELAFF (1947)

IRA H. STEIN (1947)

HENRYK B. STENZEL (1947)

D. E. TAYLOR (1948)

G. D. THOMAS (1948)

HENRY N. TOLER (1947)

C. W. TOMLINSON (1948)

GEORGES VORBE (1947)

W. O. ZIEBOLD (1947)

THE ASSOCIATION ROUND TABLE

COMMITTEE FOR PUBLICATION

LYNN K. LEE (1948), *chairman*, Pure Oil Company, Fort Worth, Texas

1947	1948	1949
J. E. BILLINGSLEY	JOSEPH L. BORDEN	JOHN G. GRAY
DON O. CHAPPELL	W. S. HOFFMEISTER	GEORGE C. GROW
J. I. DANIELS	J. M. KIRBY	BENJAMIN F. HAKE
HOLLIS D. HEDBERG	E. RUSSELL LLOYD	MASON L. HILL
LEE C. LAMAR	HOMER A. NOBLE	GEORGE S. HUME
E. A. PASCHAL	THOMAS F. STIPP	JAMES A. MOORE
K. K. SPOONER	C. W. WILSON, JR.	ROBERT B. NEWCOMBE
T. E. WEIRICH		E. A. WENDLANDT

RESEARCH COMMITTEE

SHEPARD W. LOWMAN (1947), *chairman*, Shell Oil Company, Houston, Texas

1947	1948	1949
E. R. ATWILL	RONALD K. DEFORD	WALTER R. BERGER
ROLAND F. BEERS	MARCUS A. HANNA	K. C. HEALD
PARKE A. DICKEY	W. P. HAYNES	WILLIAM C. IMBT
G. C. GESTER	MARSHALL KAY	W. C. KRUMBEIN
ROBERT N. KOLM	PHILIP B. KING	F. M. VAN TUYL
GRAHAM B. MOODY	A. I. LEVORSEN	W. A. WALDSCHMIDT
D. PERRY OLCOTT	W. W. RUBEY	
ROBERT J. RIGGS	W. T. THOM, JR.	
JOSEPH A. SHARPE		

GEOLOGIC NAMES AND CORRELATIONS COMMITTEE

HENRY J. MORGAN, JR. (1948), *chairman*, Atlantic Oil and Refining Company, Dallas, Texas

1947	1948	1949
STUART K. CLARK	JOHN G. BARTRAM	ROLLIN ECKIS
ROY T. HAZZARD	ROBERT H. DOTT	G. D. THOMAS
W. J. HILSEWECK	E. FLOYD MILLER	H. D. THOMAS
WAYNE V. JONES	HUGH D. MISER	L. E. WORKMAN
W. ARMSTRONG PRICE	RAYMOND C. MOORE	

SUB-COMMITTEE ON CENOZOIC

W. ARMSTRONG PRICE (1947), *chairman*, Box 1860, Corpus Christi, Texas

GORDON I. ATWATER	HENRY V. HOWE	TOM MCGLOTHLIN
B. W. BLANFIED	WAYNE V. JONES	PHILIP S. MOREY
MARCUS A. HANNA	F. STEARNS MACNEIL	E. A. MURCHISON, JR.

SUB-COMMITTEE ON MESOZOIC

G. D. THOMAS (1949), *chairman*, Shell Oil Company, Shreveport, Louisiana

C. I. ALEXANDER	L. R. MCFARLAND	ROBERT L. SIELAFF
RALPH W. IMLAY	E. H. RAINWATER	JAMES D. WEIR
W. D. KLEINPELL	J. R. SANDIDGE	RICHARD M. WILSON
	GAYLE SCOTT	

SUB-COMMITTEE ON PALEOZOIC

ROBERT H. DOTT (1948), *chairman*, Oklahoma Geological Survey, Norman, Oklahoma

STUART K. CLARK	E. FLOYD MILLER	RAYMOND C. MOORE
W. J. HILSEWECK	HUGH D. MISER	

COMMITTEE ON APPLICATIONS OF GEOLOGY

KENNETH K. LANDES (1947), *chairman*, University of Michigan, Ann Arbor, Michigan

1947
LEO R. FORTIER
THOMAS A. HENDRICKS
W. T. NIGHTINGALE
PAUL WEAVER

1948
ROBERT I. DICKEY
CHARLES R. FETKE
OLAF P. JENKINS
NICHOLAS A. ROSE

1949
E. M. BAYSINGER
CHARLES J. DEEGAN
L. B. HERRING
R. A. STEHR

MEDAL AWARD COMMITTEE

EARL B. NOBLE, *chairman*, Union Oil Company, Los Angeles, CaliforniaF. W. ROISHAUSEN, *ex officio*, president of S.E.P.M.J. J. JAKOSKY, *ex officio*, president of S.E.G.

1947
H. B. FUQUA
THORNTON DAVIS
HUGH D. MISER

1948
A. RODGER DENISON
VIRGIL B. COLE
J. EDMUND EATON

1949
RUSSELL S. MCFARLAND
RAYMOND F. BAKER
C. R. MCCOLLOM

COMMITTEE ON STATISTICS OF EXPLORATORY DRILLING

F. H. LAHEE (1947), *chairman*, Sun Oil Company, Box 2880, Dallas, TexasPAUL WEAVER (1948), *vice-chairman*, Gulf Oil Corporation, Box 2100, Houston, Texas

1947
ALFRED H. BELL
R. J. CULLEN
W. LLOYD HASELTINE
W. J. HILSEWECK
W. S. McCABE
JOHN C. MILLER
C. L. MOODY

1948
KENNETH COTTINGHAM
RALPH E. ESAREY
FENTON H. FINN
JOHN W. INKSTER
GRAHAM B. MOODY
CHARLES H. ROW

1949
ROBERT L. BATES
STANLEY G. ELDER
COLEMAN D. HUNTER
ROBERT C. LAFFERTY, JR.
D. J. MUNROE
T. F. PETTY
GLENN C. SLEIGHT
C. W. WILSON

DISTINGUISHED LECTURE COMMITTEE

FRED H. MOORE, *chairman*, Magnolia Petroleum Company, Mt. Vernon, Illinois

1947
LEE H. CORNELL
JOHN L. FERGUSON
W. J. HILSEWECK

1948
EVERETT F. STRATTON
CARROLL M. WAGNER

1949
HUGH R. BRANKSTONE

SPECIAL COMMITTEES

NATIONAL SERVICE COMMITTEE

M. GORDON GULLEY, *chairman*, Gulf Oil Corporation, Pittsburgh, Pennsylvania

FRITZ L. AURIN
OLIN G. BELL
CHARLES E. ERDMANN

CHARLES B. HUNT
OTTMAR F. KOTICK
LAWRENCE E. NUGENT, JR.

ED. W. OWEN
W. T. SCHNEIDER

COMMITTEE ON BOY SCOUTS LITERATURE

MAX W. BALL, *chairman*, Denver National Bank Building, Denver, Colorado

A. C. BACE

DON L. CARROLL

MEMBERSHIP APPLICATIONS APPROVED FOR PUBLICATION

The executive committee has approved for publication the names of the following candidates for membership in the Association. This does not constitute an election but places the names before the membership at large. If any member has information bearing on the qualifications of these nominees, he should send it promptly to the Executive Committee, Box 979, Tulsa 1, Oklahoma. (Names of sponsors are placed beneath the name of each nominee.)

FOR ACTIVE MEMBERSHIP

- Emory Glenn Albright, St. Petersburg, Fla.
 A. E. McKay, William B. Moore, O. C. Clifford, Jr.
 Robert Leo Alkire, Charleston, W. Va.
 J. E. Billingsley, H. J. Simmons, Jr., R. B. Anderson
 Philip Robert Allin, New Orleans, La.
 P. B. Leavenworth, H. E. Minor, Marcus A. Hanna
 John H. Brineman, Bogota, Colombia, S.A.
 J. A. Tong, Philip Andrews, A. D. Graves
 William Edward Crews, Maracaibo, Venezuela, S.A.
 L. Kehrler, Leon O. Wiringa, H. Stauffer
 Oswaldo De Sola, Caracas, Venezuela, S.A.
 Norman E. Weisbord, Ely Mencher, Vinton A. Bray
 Gerald Ernest Eddy, Lansing, Mich.
 Rex P. Grant, Harold E. Boyd, Edward J. Baltrusaitis
 Milo George Erhard, Bakersfield, Calif.
 Wallace L. Matjasic, J. H. McMasters, Evan H. Burtner
 George Herbert Hazen, Bogota, Colombia, S.A.
 Philip Andrews, J. A. Tong, A. D. Graves
 Stephen M. Herrick, Atlanta, Ga.
 V. T. Stringfield, Garland Peyton, James B. Dorr
 Charles Atwood Hickcox, Shreveport, La.
 Charles E. Decker, Robert H. Dott, V. E. Monnett
 Vincent C. Kelley, Albuquerque, N. Mex.
 C. E. Dobbin, John W. Vanderwilt, Harold S. Cave
 Fred Harlen Klaer, Jr., Indianapolis, Ind.
 V. T. Stringfield, J. Hirsch, A. Nelson Sayre
 Vincent James Mercier, Wichita, Kan.
 R. B. Downing, M. F. Bear, T. G. Wright
 Charles Newton Page, Tulsa, Okla.
 Dart Wantland, A. J. Barthelmes, Stanley W. Wilcox
 Robert George Perry, Haifa, Palestine
 F. E. Wellings, F. R. S. Henson, Thomas Williamson
 Duane H. Reno, Tulsa, Okla.
 R. J. Riggs, R. Clare Coffin, Garvin L. Taylor
 Loyal H. Wells, Dallas, Tex.
 W. W. Newton, Roland F. Beers, William B. Heroy, Jr.
 Richard Howard Zinszer, Santa Fe Springs, Calif.
 E. R. Atwill, Louis N. Waterfall, John E. Sherborne

FOR ASSOCIATE MEMBERSHIP

- Robert Lee Anderson, Long Beach, Calif.
 Robert H. Paschall, Peter H. Gardett, J. E. Kilkenny

Allan Parnell Bennison, Cartagena, Colombia, S.A.
 Nelson H. Darton, G. D. Hanna, David J. Crawford
 Curran Roland Campbell, Houston, Tex.
 V. E. Monnett, C. G. Lalicker, Robert H. Dott
 George E. Carver, Jr., Charleston, W. Va.
 V. E. Monnett, F. A. Melton, Joe A. Laird
 William Warren Davis, Tulsa, Okla.
 B. B. Weatherby, R. S. Knappen, W. E. Bernard
 Ralph Lewis Gutke, San Antonio, Tex.
 Carey Croneis, Ben B. Cox, Fred H. Wilcox
 Shirley Edmands Lenderman, Wichita, Kan.
 T. G. Wright, Lee H. Cornell, Caldwell Starkey
 Neil Warren Mann, Dallas, Tex.
 Eugene McDermott, Cecil H. Green, Barney Fisher
 William Byron Maxwell, Charleston, W. Va.
 J. E. Billingsley, Robert C. Lafferty, H. J. Simmons, Jr.
 Guy Russell Pierce, Ambato, Ecuador, S.A.
 William E. Wallis, Charles A. Durham, L. A. Smith
 William Donald Rogers, Ridgewood, N. J.
 V. E. Monnett, F. A. Melton, Charles E. Decker
 Freeland Howard Stevens, Jr., Tulsa, Okla.
 R. J. Riggs, R. Clare Coffin, Garvin L. Taylor
 Roy Jackson Tribbey, Jr., Caracas, Venezuela, S.A.
 Roy W. Pearce, Norman E. Weisbord, P. P. Conrad
 David Lee Welsh, Billings, Mont.
 W. T. Thom, Jr., David J. Crawford, Edward C. Dapples

FOR TRANSFER TO ACTIVE MEMBERSHIP

Richard Stewart Ballantyne, Jr., Long Beach, Calif.
 Robin Willis, C. G. Willis, M. Van Couvering
 James Dudley Davies, Centralia, Mo.
 Clinton Engstrand, John W. Inkster, T. C. Peters
 Thomas Henning Green, Tulsa, Okla.
 Sherwood Buckstaff, Robert B. Wing, G. S. Lambert

REGIONAL MEETING, BILOXI, MISSISSIPPI, OCTOBER 24-25, 1946¹GORDON I. ATWATER²

New Orleans, Louisiana

The mid-year meeting of the A.A.P.G. was held at the Buena Vista Hotel, Biloxi, on the Mississippi Gulf Coast. The Mississippi Geological Society sponsored the meeting, and the officers and committees that arranged and conducted the program can indeed be complimented on its success.

Registrations totaled 477 members and 110 guests, including a good representation of wives. Earl Noble, president of the A.A.P.G., D. Perry Olcott, vice-president, Edward A. Koester, secretary-treasurer, Gayle Scott, editor, and Monroe G. Cheney, past-president, were present. Hotel accommodations were excellent, and the inconvenience of those not registered in the headquarters hotel was more than offset by the beauty of the coast along which the other hotels were located. Our hosts had every reason to be proud of the delightful winter Gulf Coast weather that lasted throughout the meeting.

¹ Manuscript received, November 20, 1946.² Consulting geologist, 1034 Whitney Building.

The technical program was devoted to the geologic features of the southeastern states. It was well balanced between regional studies and summaries, and detailed reports on a number of the characteristic fields. Sufficient time was given each speaker to present his paper in detail, and the meetings benefited by emphasis on fewer papers, well and fully presented. There was a lack of general discussion, however, following the papers which might well be encouraged at mid-year meetings where time is less of a premium. If necessary, discussions could in part be planned in advance.



FIG. 1.—MISSISSIPPI GEOLOGICAL SOCIETY CONVENTION HEADS AND ASSOCIATION OFFICERS, BILOXI REGIONAL MEETING.

Left to right: CARL F. GRUBB, HARRY H. EMMERICH, JOE B. WHEELER, J. B. STOREY, H. L. SPYRES, M. E. NORMAN, E. B. NOBLE (president, A.A.P.G.), F. F. MELLEN, R. M. HARRIS, PERRY OLCOTT (vice-president, A.A.P.G.), GAYLE SCOTT (editor, A.A.P.G.), C. W. ALEXANDER, B. W. ALLEN.

General comment appeared to be in favor of the Association encouraging mid-year meetings of this type for the presentation of technical papers dealing with restricted areas, where the majority of those present will be interested in practically every paper. As the Association grows, it is possible that the emphasis of annual meetings should be on business, with the technical program restricted to problems of nation-wide interest, while mid-year meetings be systematically developed into symposiums devoted to technical papers on specific areas or regions.

The program of the Biloxi meeting follows.³

³ Abstracts of the Biloxi meeting papers were published in the November *Bulletin*, pp. 1963-68.



FIG. 2.—BANQUET GROUP AT BILOXI MEETING.

Left to right: E. A. MARKLEY, MRS. R. E. SHUTT, STEFAN VON CROY, MRS. ROBERT MORTON, ROBERT MORTON, R. E. SHUTT, MRS. C. N. VALERIUS, C. N. VALERIUS, MRS. R. J. RIGGS, R. J. RIGGS.



FIG. 3.—BUENA VISTA HOTEL, BILOXI MEETING HEADQUARTERS.

OCTOBER 24

Presiding in Forenoon, J. B. Storey

ADDRESS OF WELCOME, Alexander McKeigney, executive-secretary to the Governor of Mississippi

RESPONSE, F. F. Mellen, president of the Mississippi Geological Society

RESPONSE, Earl B. Noble, president of the American Association of Petroleum Geologists

INTRODUCTORY REMARKS relative to the conduct of the technical sessions and entertainment, J. B. Storey

HISTORICAL NOTES ON THE GEOLOGY OF MISSISSIPPI, Urban B. Hughes, consulting geologist, Laurel, Mississippi

STRATIGRAPHY AND PETROLEUM GEOLOGY OF BLACK WARRIOR BASIN, MISSISSIPPI AND ALABAMA, Frederic F. Mellen, Mellen & Monsour, Jackson, Mississippi

SURFACE OCCURRENCE OF CRETACEOUS BEDS IN THE SOUTHEASTERN STATES, Watson H. Monroe, United States Department of the Interior, Geological Survey, Washington, D. C.

SUBSURFACE OCCURRENCE OF CRETACEOUS SEDIMENTS OF MISSISSIPPI, C. W. Alexander, Dixie Geological Service; R. M. Harris, Harris & Payne, Jackson, Mississippi

Presiding in Afternoon, K. K. Spooner

CENOZOIC DEPOSITS OF MISSISSIPPI AND ADJACENT AREAS, Grover Murray, Jr., Magnolia Petroleum Company, Jackson, Mississippi

STATUS OF MICROPALAEONTOLOGY IN THE EASTERN GULF REGION, Henry V. Howe, Louisiana State University, Baton Rouge, Louisiana

GENERAL GEOLOGY AND OCCURRENCE OF OIL IN FLORIDA, E. D. Pressler, Humble Oil and Refining Company, Tampa, Florida

BANQUET—Henry Toler, toastmaster, Rose Room, Buena Vista Hotel

President Earl B. Noble discussed Association affairs. Elmer W. Ellsworth, assistant business manager of the A.A.P.G. talked informally on the growth of the business handled by our main office through the years of expansion of the society. The dance on the Deck of the Buena Vista Hotel, following the banquet, was well attended.

OCTOBER 25

Presiding in Forenoon, M. L. Kerlin

SUBSURFACE CORRELATIONS OF EAST TEXAS, NORTH LOUISIANA, SOUTH ARKANSAS, AND MISSISSIPPI, Roy T. Hazzard, Gulf Refining Company, Shreveport, Louisiana

FORMATION OF EVAPORITES UNDER MARINE EVAPORATION CONDITIONS, Paul Weaver, Gulf Oil Corporation, Houston, Texas

MESOZOIC IGNEOUS ROCKS OF THE NORTHERN GULF COASTAL PLAIN, C. L. Moody, The Ohio Oil Company, Shreveport, Louisiana

GEOLOGY OF THE WEST TEPETATE OIL FIELD, JEFF DAVIS PARISH, LOUISIANA, Fred W. Bates and Jay B. Wharton, consulting geologists, Lafayette, Louisiana

Presiding in Afternoon, U. B. Hughes

THE DELHI, WEST DELHI, AND BIG CREEK FIELDS, RICHLAND, MADISON AND FRANKLIN PARISHES, LOUISIANA, A. M. Lloyd, Sun Oil Company, Dallas, Texas; R. B. Totten, Sun Oil Company, Monroe, Louisiana

GEOLOGY OF THE GILBERTOWN FIELD, CHOCTAW COUNTY, ALABAMA, A. M. Current, Carter Oil Company, Jackson, Mississippi

THE TINSLEY FIELD, F. R. Schroeder, Union Producing Company, Shreveport, Louisiana; J. B. Storey, Union Producing Company, Jackson, Mississippi

THE CRANFIELD FIELD, ADAMS AND FRANKLIN COUNTIES, MISSISSIPPI, George P. Zebal, The California Company, Natchez, Mississippi

THE HEIDELBERG FIELD, JASPER COUNTY, MISSISSIPPI, Tom McGlothlin, Gulf Refining Company, Laurel, Mississippi

MID-CONTINENT REGIONAL MEETING, WICHITA, KANSAS, JANUARY 16-17, 1947

A regional meeting of the American Association of Petroleum Geologists, sponsored by the Kansas Geological Society, will be held at Wichita, Kansas, with the Broadview Hotel as headquarters. Papers cover unusual fields and future of Mid-Continent.

The Broadview Hotel can not accommodate the entire attendance anticipated, but all requests for reservations should be addressed directly to the Broadview Hotel, which

will handle transfers of reservations to the Allis, Lassen, and other Wichita hotels. Each of these is located within one-half mile radius of the headquarters hotel.

It is imperative that the committee know, as near as possible, how many will attend; accordingly, please return promptly the card that has been mailed you, indicating the possibility of your attendance.

Registrations will begin at noon, Wednesday, January 15. The research committee will meet all day Wednesday. The geologic names and correlations committee also meets. An informal Open House will be held in the Bamboo Room of the Broadview, at 8 P.M., January 15.

On January 16, there are meetings of the distinguished lecture committee and the committee on applications of geology.

On the night of January 16, a dance is planned, and entertainment for the ladies is also planned for the afternoon of January 17.

Some of the papers scheduled for presentation at this meeting are here listed.

1. Unusual Oil Fields of the Rocky Mountain Province, by C. E. Dobbin
2. Norman Wells Oil Field, Canada, by J. S. Stewart
3. Deep River Pool, Michigan, by K. K. Landes
4. Adams Pool, Michigan, by Rex P. Grant
5. Pools of Genesee Trend, Kansas, by Stuart K. Clark
6. Marine Pool, Madison County, by H. A. Lowenstam
7. Hugoton Gas Field, Kansas, by L. C. Morgan *et al.*
8. Rangely Oil Field, by J. M. Kirby *et al.*
9. Antioch Pool, Garvin County, Oklahoma, by Lon B. Turk
10. West Edmond Field, Oklahoma, by Robert M. Swesnik
11. Kraft-Prusa Field, Kansas, by R. F. Walters
12. Moren-Kisinger Pool, North-Central Texas, by M. G. Cheney
13. Geophysical Case History of Guthrie Field, Oklahoma, by B. G. Swan and W. Baxter Boyd.
(Sponsored by Society of Exploration Geophysicists.)
1. Structural Framework of the Mid-Continent Region, by Ira H. Cram
2. Anadarko Basin and Its Oil Possibilities, by Robert R. Wheeler
3. Oil Possibilities of the Las Animas Arch, by Harry W. Osborne
4. Subdivisions of the Arbuckle Dolomite in Western Kansas, by Joseph R. Clair
5. Role of Geophysics in Future Development of Mid-Continent, by Gerald H. Westby
6. Radioactivity Well Logging, by V. J. Mercier
7. Detailed Core of Hunton Limestone in West Edmond Field, by J. T. Richards

FUNCTIONS AND ORGANIZATION OF GEOLOGIC NAMES AND CORRELATIONS COMMITTEE¹

HENRY J. MORGAN, JR.²

Dallas, Texas

It is the desire and aim of the geologic names and correlations committee to enlist the aid of the affiliated societies, sections, and local groups in large-scale cooperative projects having to do with the nomenclature and correlation of formations located in the areas of interest to them.

Since the interest of the cooperating groups lies in areas which, geographically, cover a sizeable part of the United States and a part of Canada and, geologically, include the entire geologic section, it is at once apparent that the organization must be large and it must be able to function simultaneously in all parts of the country and in all parts of the section.

¹ Manuscript received, October 7, 1946.

² Chairman of the committee. Atlantic Oil and Refining Company.

It is equally apparent that the task would be a full-time job for a number of competent geologists if they intended to perform it alone. However, if a method can be devised to tap systematically the mass knowledge of the 31 local groups and, if this method can break the work into small enough parts so that each society performs only a small part of a large project, then it is believed that the organization outlined in Table I can realize its aim.

In this organization outline, the geologic column is divided into three parts: Cenozoic, Mesozoic, and Paleozoic. The country is divided into geographical areas that include the best development of beds of Cenozoic, Mesozoic, and Paleozoic ages.

TABLE I

ORGANIZATION CHART OF GEOLOGIC NAMES AND CORRELATIONS COMMITTEE

President and Executive Committee of A.A.P.G.

Geologic Names and Correlations Committee

Cenozoic Sub-Committee

District Committee Study Groups

Western Gulf Coast

1. South Texas Section of A.A.P.G.
2. Corpus Christi Geological Society
3. Houston Geological Society
4. South Louisiana Geological Society
5. New Orleans Geological Society
6. East Texas Geological Society
7. Shreveport Geological Society

Eastern Gulf Coast

1. Mississippi Geological Society
2. Southeastern Geological Society
3. New Orleans Geological Society

Atlantic Coast

1. Southeastern Geological Society
2. Eastern Section of A.A.P.G.

Rocky Mountains and Great Plains

1. Rocky Mountain Association of Petroleum Geologists
2. Wyoming Society of Petroleum Geologists
3. Alberta Society of Petroleum Geologists
4. Yellowstone-Bighorn Research Association

Pacific Coast

1. Pacific Section of A.A.P.G.
2. San Joaquin Valley Geological Society

Mesozoic Sub-Committee

District Committee Study Groups

Gulf Coast

1. South Texas Section of A.A.P.G.
2. Fort Worth Geological Society
3. Dallas Geological Society
4. East Texas Geological Society
5. Shreveport Geological Society
6. Mississippi Geological Society
7. Southeastern Geological Society

Atlantic Coast

1. Southeastern Geological Society
2. Eastern Section of A.A.P.G.

Rocky Mountains and Great Plains

1. Rocky Mountain Association of Petroleum Geologists
2. Wyoming Geological Association
3. Alberta Society of Petroleum Geologists
4. Yellowstone-Bighorn Research Association

Pacific Coast

1. Pacific Section
2. San Joaquin Valley Geological Society

Paleozoic Sub-Committee

District Committee Study Groups

Rocky Mountains and Great Plains

1. Rocky Mountain Association of Petroleum Geologists
2. Wyoming Geological Association
3. Yellowstone-Bighorn Research Association
4. Alberta Society of Petroleum Geologists

Mid-Continent

1. Mississippi Geological Society
2. Oklahoma City Geological Society
3. Shawnee Geological Society
4. Tulsa Geological Society
5. Kansas Geological Society

Eastern Interior

1. Indiana-Kentucky Geological Society
2. Illinois Geological Society
3. Michigan Geological Society
4. Mississippi Geological Society

Southwestern United States

1. West Texas Geological Society
2. Panhandle Geological Society
3. North Texas Geological Society
4. Fort Worth Geological Society
5. Ardmore Geological Society
6. Dallas Geological Society
7. South Texas Section of A.A.P.G.

Appalachian Region

1. Appalachian Geological Society
2. Eastern Section of A.A.P.G.
3. Pittsburgh Geological Society

Advisory and Special Projects Sub-Committee

Temporary Committees

Each of the three main geologic divisions is covered by a chairman and a sub-committee. The members of each sub-committee are co-chairmen of geographical districts which contain well developed beds of the age in question.

The district co-chairmen, in turn, have committees whose membership is drawn from the local societies in their districts. They can have as many men on their committee as they wish, but each local society or other group should be represented on these district committees.

Each society in each district will be asked to appoint a study group to cooperate upon some project whose importance is mutually agreed on. The geologic names and correlations committee representative in each society should be a member of the study group, but should not necessarily be its chairman.

The outline contemplates, also, the formation of an advisory committee whose members will act as consultants on matters submitted to them and will handle special projects turned over to the main committee by the Association executive committee. This committee will have rank equal to that of the other sub-committees.

Since many of the projects will involve the making of cross sections and correlation charts, portions of which will be divided among the societies along the route, it is planned for each society to submit its part for publication, together with text giving its reasons for correlations, as soon as completed.

THE ASSOCIATION ROUND TABLE

NOMINEES FOR OFFICERS, 1947-1948

FOR PRESIDENT



C. E. DOBBIN



JOHN G. BARTRAM

C. E. DOBBIN, Regional Geologist, United States Geological Survey, Denver, Colorado
Born, West Jonesport, Maine, October 2, 1892

Academic Training

Colby College
Colby College
Johns Hopkins University

Geology A.B., 1916
Honorary Ph.D., 1941
Geology Ph.D., 1924

Experience

U. S. Geological Survey 1918-

Publications—Field of structural geology, and geology of oil, gas, and coal

Professional Affiliation (National)

American Association for the Advancement of Science
American Geophysical Union
American Institute of Mining and Metallurgical Engineers
American Society of Photogrammetry
Geological Society of America

A.A.P.G. Activity

1932	Constitution and By-Laws Committee
1932-1938	Research Committee
1932-1936; 1939-1941	Business Committee
1933-1935	Associate Editor
1936	Vice-President
1939	Committee on Methods of Electing Officers
1939, 1943-1945	(vice-chm); 1945 (chm): Committee for Publication
1939-1942	Committee on Applications of Geology (chm, 1939-1941)
1943-1944	Geologic Names and Correlations Committee, Sub-Committee on Mesozoic
1946	Representative on Council of American Association for the Advancement of Science

JOHN G. BARTRAM, Assistant Manager of Exploration, Stanolind Oil and Gas Company, Tulsa, Oklahoma

Born, Lakeville, Connecticut, November 27, 1893

Academic Training

Williams College, 1910-1914

Williams College, 1914-1915

Johns Hopkins University, 1915-1916

Chemistry B.A., 1914

Geology Graduate Work

Geology Graduate Work

Experience

Roxana Petroleum Corporation 1916-1923

Midwest Refining Company 1923-1932

Stanolind Oil and Gas Company 1932-

Military Service—Ordnance, 1918-1919

Publications—Field of petroleum geology

Professional Affiliation (National)

Geological Society of America

A.A.P.G. Activity

1933-1945; 1937-1945 (chm)

1936-1938

1942-1946; 1944 (chm)

1944-1945 (chm)

Geologic Names and Correlations Committee

Research Committee

Representative on Commission on Classification and Nomenclature of Rock Units

Committee on Method of Election of Officers

FOR VICE-PRESIDENT



GEORGE S. BUCHANAN

GEORGE S. BUCHANAN, Manager, Gulf Coast Division, Sohio Petroleum Company, Houston, Texas
Born, Sterling, Colorado, September 1, 1902

Academic Training

University of Michigan, 1920-1922

University of Michigan, 1923-1924

Geology A.B., 1922

Geology M.S., 1924

Experience

Pure Oil Company	1924-1925
Carter Oil Company	1925-1928
Tulsa Oil Company	1928-1932
Barnsdall Oil Company	1932-1933
Adams Louisiana Company	1934-1939
Yegua Corporation	1940-1944
Sohio Petroleum Company	1945-

Military Service—Infantry, 1918*Publications*—Field of petroleum geology*A.A.P.G. Activity*

1939-1940	Trustee of Revolving Publication Fund
1940	Committee to Recommend a New Way of Electing Officers
1940	Committee on Mimeographed Publications
1942-1943	Committee on Applications of Geology
1945-1946	Business Committee (chm, 1945)

FOR SECRETARY-TREASURER



J. V. HOWELL

J. V. HOWELL, Consultant, Tulsa, Oklahoma
 Born, Oskaloosa, Iowa, March 11, 1891

Academic Training

Penn College (Iowa), 1908-1912	Chemistry B.S., 1912
University of Iowa, 1913-1916	Geology M.S., 1916
University of Iowa	Geology Ph.D., 1921

Experience

The Texas Company	1916-1918
Gypsy Oil Company	1918-1921
University of Iowa, Instructor in geology	1921-1922
Marland Oil Company	1922-1929
Consulting Geologist, Tulsa, Oklahoma	1929-

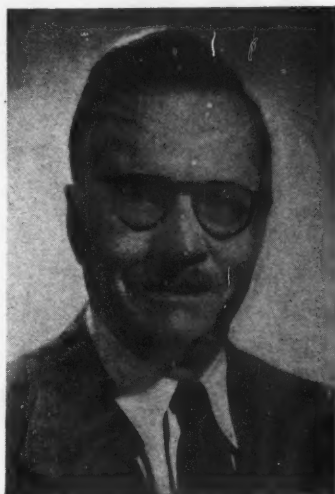
Military Service—Field Artillery, 1918*Publications*—Field of structural, economic, and petroleum geology

Professional Affiliation (National)
 Geological Society of America

A.A.P.G. Activity

- | | |
|------------|---|
| 1927; 1939 | Business Committee |
| 1930 | Committee on Method of Election of Officers |
| 1936-1938 | Trustee of Revolving Publication Fund |
| 1940 | Committee for Recommending a New Way for Electing Officers |
| 1942-1944 | Chairman, Committee for Publication |
| 1945 | Vice-Chairman, Committee for Publication |
| 1946 | Editor of Volume III, <i>Structure of Typical American Oil Fields</i> |

FOR EDITOR



C. L. MOODY

C. L. Moody, Division Geologist, The Ohio Oil Company, Shreveport Louisiana
 Born, Compton, California, October 26, 1888

Academic Training

- | | | |
|-----------------------------------|-----------|--------------------------|
| University of Southern California | 1909-1910 | |
| University of California | 1912-1916 | Geology A.B., 1916 |
| University of California | 1917 | Geology Graduate Student |

Experience

Consulting Geologist, Casper, Wyoming, 1917-1918
 The Ohio Oil Company, 1918-

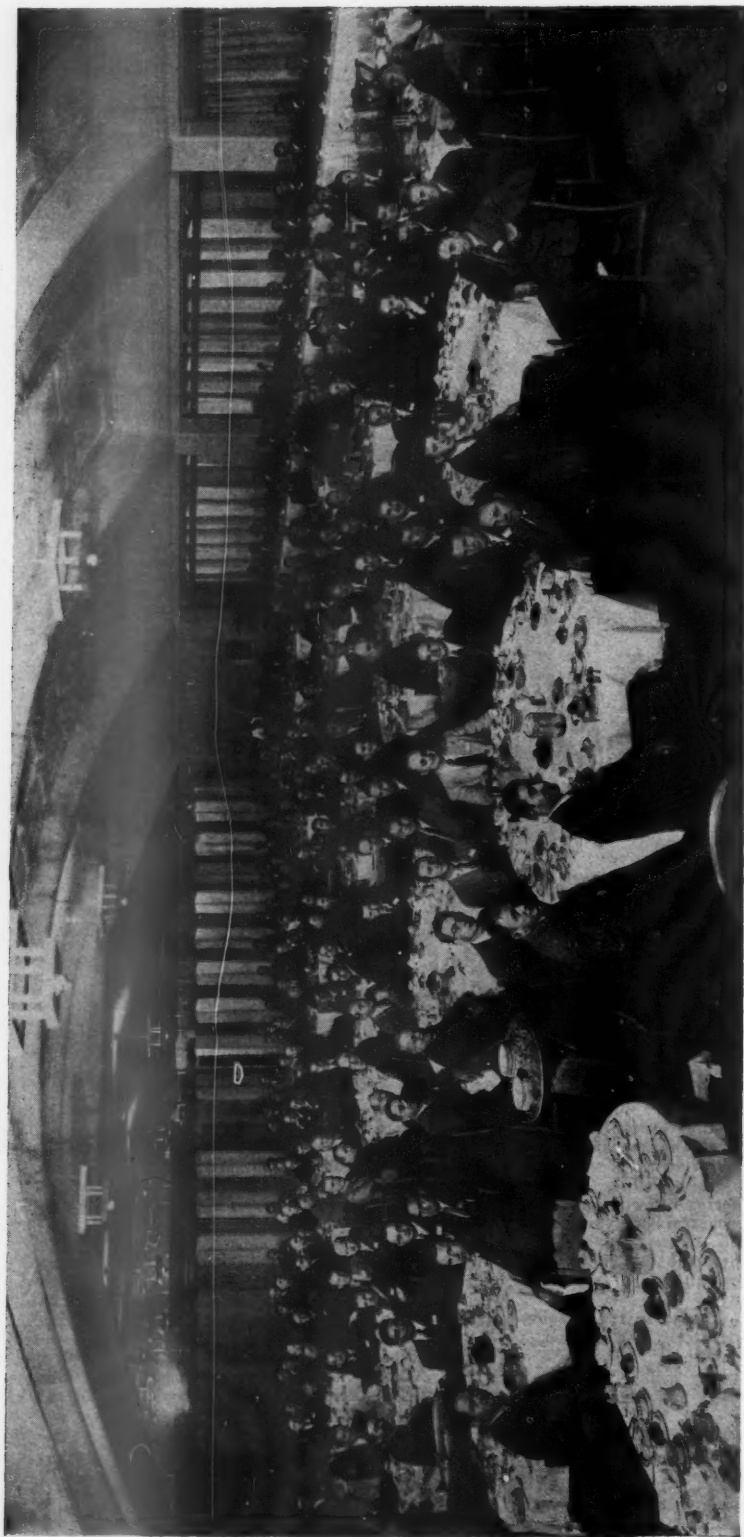
Publications—Field of stratigraphy and structure of Rocky Mountain and Gulf Coast areas

Professional Affiliation

American Association for the Advancement of Science
 Geological Society of America

A.A.P.G. Activity

- | | |
|---------------------------------------|---|
| 1932-1940 | Geologic Names and Correlations Committee |
| 1933-1938 | Associate Editor |
| 1937 | Vice-President |
| 1937; 1939-1941; 1946 (vice-chm, chm) | Business Committee |
| 1943-1945; 1945 (chm) | Trustee of Research Fund |
| 1943-1944 | National Service Committee |
| 1945 | Committee on Statistics of Exploratory Drilling |
| 1945 | Committee on Method of Election of Officers |



Pacific Section annual meeting luncheon in Embassy Room, Ambassador Hotel, November 7.

PACIFIC SECTION ANNUAL MEETING, LOS ANGELES,
CALIFORNIA, NOVEMBER 7-8, 1946

The Pacific Section of the Association held its annual meeting, November 7 and 8 at the Ambassador Hotel, Los Angeles. Concurrently meeting with the A.A.P.G. were the Pacific Section of the Society of Economic Paleontologists and Mineralogists and the Pacific Coast District of the Society of Exploration Geophysicists.

The officers of the A.A.P.G. Pacific Section whose terms ended with this meeting are: E. R. Atwill, president; V. W. Vandiver, vice-president; and A. S. Holston, secretary-treasurer. The program committee was composed of J. R. Dorrance, chairman, Wayne Loel and J. E. Matter. The arrangements committee was Frank Carter, chairman; Lloyd Metzner, and Harold Rader. Publicity was handled by Gordon Bell.

Incoming officers elected at this meeting are: president, Martin Van Couvering, consultant; vice-president, W. P. Winham, Standard Oil Company of California; and secretary-treasurer, Clifton Johnson, Richfield Oil Corporation.

The registration of geologists, geophysicists, paleontologists, and friends numbered 450. About 200 attended the joint luncheon of the 3 groups at noon the first day, when committeemen and guests were introduced by toastmaster Atwill, and national A.A.P.G. president E. B. Noble discussed research problems of the Association and gave a digest of the papers presented at the Biloxi, Mississippi, regional meeting, which was held on October 24 and 25. Representing the national headquarters staff at Tulsa, Oklahoma, assistant business manager E. W. Ellsworth and business manager J. P. D. Hull made brief remarks. A special feature of the luncheon ceremony was the presentation of a wrist watch to Martin Van Couvering as a token of esteem from the members of the Pacific Section Geological Forum, of which he is chairman.

The annual dinner dance of the Section was the social event of the meeting, held in the Embassy Room of the Ambassador Hotel on Friday evening, November 8.

The following are the titles and abstracts of the papers on the technical program of the Section, including those of the S.E.P.M.

PACIFIC SECTION ABSTRACTS

1. "Notes on the Stratigraphy of the Santa Maria District," ADEN W. HUGHES, Union Oil Company, Santa Maria.

Seven oil fields in the Santa Maria District produce oil from four different formations. The most prolific of these is the Monterey shale (middle and upper Miocene). Oil in the Knoxville sandstone, discovered in 1943, created a mild drilling boom, but was limited in areal extent. Lospe production is the latest economic interest in the district. Variation in the age of the Monterey cherty shale in the Santa Maria Valley and other fields makes correlations difficult. Ditch sampling of development as well as wildcat wells has been a valuable practice in stratigraphic control and aid in electrolog correlations. Microscopic study of washed samples shows definite lithologic changes that carry over wide areas.

2. "The Ostracoda in Paleogeography," W. T. ROTHWELL, JR., Richfield Oil Company, Long Beach

A study of the depth-distribution of recent ostracods in the San Pedro Channel from Long Beach to Avalon Bay, Catalina Island, has revealed a new tool to aid in the solution of paleogeographic and ecologic problems in California stratigraphy. These microscopic crustaceans are very abundant in shallow salt-water lagoons, in mainland continental shelf sediments down to a water depth of 500 feet, and along protected island shores. The samples collected by Alex Clark and Manley L. Natland show by the presence of soft parts that the more abundant species of ostracods were alive on the bottom when dredged.

Comparison with the 26 fossil forms recorded by L. W. LeRoy in 1944 reveals eighteen of his species and varieties surviving to Recent time. Total recent forms recognized to date number approximately 22 genera, 52 species, and 7 subspecies.

The following geologic formations and Recent ostracod habitats are grouped together to suggest similar environments, as inferred from the occurrence in each of certain characteristic genera and species.

- I. Lower San Joaquin Formation (Upper Pliocene) and Salton Sea deposits (Recent?)
- II. Upper Etchegoin Formation (Pliocene) and Sunset Lagoon (Recent), Salt marshes of Mission Bay (Recent)
- III. Upper Imperial Formation (Pliocene) and shore waters of the Gulf of California (Recent), mouth of Mission Bay (Recent)
- IV. Upper Pico Formation (upper Pliocene or Pleistocene), Lower Etchegoin Formation (Pliocene), lower Imperial Formation (Pliocene or Miocene), Upper Wildcat Series (Upper Pliocene) and Pacific Coast, exposed, continental shelf bottom deposits
- V. Lomita marl (Lower Pleistocene or Upper Pliocene) and Catalina Island lee shore marl (Recent)

Slides are presented to show locality map, anatomy, representative species, and occurrences in the Pliocene of the Midway-Sunset oil field, Kern County, California.

3. "The Glendora Volcanics," JOHN S. SHELTON, Pomona College, Claremont.

The term Glendora volcanics has been given to the series of volcanic rocks exposed in the north-eastern San Gabriel basin, Los Angeles County, California. They consist of flows, tuff breccias, and tuffs ranging in composition from olivine basalt to glassy rhyolite or dacite, the most abundant being andesitic flows and pyroclastics. Thicknesses reach at least 2,000 feet in exposed sections and about 3,500 feet in wells. Luisian Foraminifera and fish scales from sediments interbedded with upper members of the volcanics indicate that they are probably largely of upper middle Miocene age.

4. "Highlights of Washington and Oregon Biostratigraphy," R. STANLEY BECK, consulting paleontologist, Bakersfield.

The biostratigraphy of type and classical localities of Washington and Oregon is discussed. Special emphasis is given to the Astoria, Cowlitz, Olympic peninsula and Coos Bay basins. Strata from Devonian to Recent are known from these areas and have a combined thickness of over 30,000 feet. These basins, as well as others, are possible areas in which oil and gas might be discovered in the future. Favorable as well as unfavorable geologic conditions will be discussed concerning oil possibilities of the Pacific Northwest.

5. "Tidal Waves from the Recent Aleutian Earthquake," FRANCIS P. SHEPARD, Scripps Institution of Oceanography, La Jolla.

On April 1, 1946, a sudden movement of the ocean bottom in the Aleutian deep started a train of sea waves which were picked up on tide gauges as far away as Australia and South America. Great damage was done to all of the north coasts of the Hawaiian Islands and the waves surged to heights as great as 55 feet in some places of convergence. Investigation of the five main Hawaiian islands showed relationships between high water marks and submarine topography. Also the height was greatly influenced by the existence of coral reefs and lagoons along the shore. Investigations in Hawaii have been compared with determinations by the Japanese in the 1933 tidal waves to devise a means of forecasting the relative danger of different situations from future tidal waves.

Personal experiences during the tidal wave are given along with accounts of other observers.

6. "Effects of World War II on California Oil Reserves," Graham B. Moody, Standard Oil Company of California, San Francisco.

The enormous demands of World War II for California oil were met successfully. Production was increased from 230,263,000 barrels in 1941 to 326,555,000 barrels in 1945. This is an increase of 41.8%. The comparable figure for the balance of the United States is 18%. During the period 1941 to 1945, inclusive, California produced 18.2% of total United States oil production and 11.7% of total world production. It increased its proportion of total United States production from 16.4% in 1941 to 19.1% in 1945. One other record of past performance is of interest: California had produced to December 31, 1945, about 22% and 14% of total cumulative production from the United States and the world, respectively. This performance was accomplished by development of about 245,000 proved productive acres, a small area compared to that in other producing states. Average ultimate recovery from California fields is estimated to be about 44,000 barrels per acre. Other major producing states have estimated ultimate recoveries of 8,000 to 14,000 barrels per acre. California pools have sufficient thickness to compensate for their restricted areal extent.

Despite the drain on California's oil resources by World War II, production in the middle of September, 1946, was about 870,000 barrels daily; the daily average during 1941 was about 631,000 barrels. During the period 1941 to 1945, inclusive, the discovery of new pools and new fields in California added estimated reserves equal to about one-third of production during that period. Additional reserves must be discovered in order to continue to meet the unprecedented peacetime demand for California oil. More new pools in present producing areas probably will add larger amounts to reserves than will new fields (Tidelands excepted). It will require intensified geological effort to find

these new reserves. There still is ample opportunity in California for the competent and imaginative geologist who can evolve a productive program from a mass of factual information.

7. "Time of Oil and Gas Accumulation," A. I. LEVORSEN, Stanford University.

A perplexing problem in petroleum geology is whether the oil and gas originate at or very near the point of accumulation, or whether they have migrated in from some distant area of origin. Examples of both *in situ* and distant origin can be cited that seem to indicate both occur in nature.

For those pools which seem to indicate migration from a distant source, a rough guide as to the time of the accumulation is offered. It is based on the timing of the formation of the trap into which the oil and gas accumulate—the accumulation cannot occur before the trap is formed. In considering the interval between the time of formation of the reservoir rock and the present time, most producing traps can be separated into the varying component elements which go to make up the trap as it now exists. Examples of different combinations of trapmaking events are given as a guide to the time before which accumulation could not have occurred. Furthermore, the capacity of a trap is in part a function of the depth of burial of the reservoir—a phenomenon which also supports a relatively late accumulation of many pools.

8. "Permafrost and Related Engineering Problems," SIEMON WM. MULLER, Stanford University.

Permafrost or permanently frozen ground is a widespread phenomenon in the northern hemisphere. About one-fifth of all land area of the world is underlain by permafrost.

Wherever present, permafrost affects in one way or another (or is itself affected by) every field of human endeavor. The consideration of permafrost is vital in planning transportation routes, settlements, pipelines, drilling operations, etc. Roads, railroads, and buildings, inappropriately located or improperly designed and built, are likely to be damaged and rendered useless. Drilling tools may freeze in the hole, causing the abandonment of a project. In the permafrost area, the problem of water supply claims foremost attention.

Stresses that develop in freezing ground may exceed 2,000 kilograms per square centimeter. Just as the Russians have done in the past, we are learning, in the hard way, that it is uneconomical if not futile to "fight" the natural forces of frost by using stronger materials, more rigid designs, or to resort to periodic and costly repairs, which rarely if ever succeed in a permanent righting of the situation. Successful solution of permafrost problems depends on a thorough understanding and correct quantitative evaluation of the component elements and on the planning of the project in such a way that the frost forces are utilized to play into the hand of the engineer and not against it. A thorough and comprehensive survey of the permafrost conditions should therefore constitute a preliminary and an integral part of any engineering project.

9. "The Cretaceous of Colombia," J. WYATT DURHAM, California Institute of Technology, Pasadena.

During the Cretaceous varying amounts of marine and non-marine sediments were deposited in the North Andean geosyncline which passed through Venezuela, Colombia, and Ecuador. During the maximum period of flooding, all except extreme Western Colombia, part of Eastern Colombia, and a few islands appear to have been covered by the seaway. The Cretaceous sediments usually begin with a sandstone or limestone, which is followed by a thick sequence of black shales with occasional limestone members. Following the black shales, there is a more or less cherty shale or limestone, which is followed by either sands and shales or shales and limestones. The thickness of the sediments varies from around 2,000 feet to more than 40,000 feet. Marine faunas are often abundant and show marked relationships to both the Gulf Coast and the European Cretaceous faunas. From the faunas collected at various localities it appears that most, if not all of the standard Cretaceous section is represented in Colombia.

10. "Origin and Migration of Oil into Sespe Red Beds," THOMAS L. BAILEY, Rothschild Oil Company, Santa Fe Springs.

The name "Sespe formation" is applied to the non-marine red bed facies of a group of sedimentary rocks up to 7,500 feet thick. They range in age from upper Eocene into lower Miocene in the southern and eastern part of the Ventura basin but are probably confined to the Oligocene in most of the northwestern part of that basin. The lower portion becomes progressively marine westward beginning about 25 miles west of Santa Barbara, however, this marine Oligocene is mainly sandstone, low in organic material, and can hardly be a source rock.

The bulk of the evidence suggests that most of the oil was derived from Eocene shales. Upward migration across the bedding of several hundred to a few thousand feet of predominantly sandy strata seems to be required. Countless minor joints and cracks in the shaly interbeds are suggested as the principal channels of upward migration. In the southeastern part of the Ventura basin, some of the oil may have reached the lower, or Eocene portion of the Sespe by lateral migration from upper Eocene shales into which the lower Sespe may grade, followed by upward migration within the anticlines to the shallier middle Sespe where it is trapped.

11. "Evidence Supporting Lateral Migration of Oil, San Joaquin Valley, California," GLENN C. FERGUSON, consulting paleontologist, Bakersfield.

Considerable evidence has been presented from time to time in various geologic publications favoring the accumulation of oil derived from "local rich accumulations of organic matter deposited in restricted areas near to, indigenous to, or in contact with the reservoir and trap." Opposed to this view, other authors have favored substantial migration, either lateral or vertical, or both.

Evidence is presented strongly supporting, if not conclusively proving that oil, when provided the proper avenue for underground movement, does migrate laterally over distances of several miles. Nothing is implied to indicate that oil may not have accumulated locally, having been derived from restricted areas, underground stratigraphic, and structural conditions being the governing factors at all times.

12. "Accumulation of Oil in Continental Sediments at the South Belridge Oil Field, Kern County, California," E. J. COENEN and H. D. HOBSON, General Petroleum Corporation, Bakersfield.

Factual data are presented concerning the accumulation of oil in continental sediments at the South Belridge oil field. Included are the structure and stratigraphy of the field, the reservoir characteristics of the sediment and the properties and distribution of the oil and associated waters. The lithology, organic content, and included fluids of adjacent marine sediments are discussed with the objective of making tentative suggestions as to the origin, migration, and accumulation of the oil.

13. "Petroleum on the Continental Shelves," WALLACE PRATT, American Association of Petroleum Geologists Distinguished Lecturer, Frijole, Culberson County, Texas.

President Truman's executive proclamation of September 25, 1945, declaring the continental shelf contiguous to our coasts to be subject to our jurisdiction and control, fell upon the ears of a petroleum industry which in its worldwide search for new sources of supply, had already found its exploratory operations on more than one continent brought to a stop at the land's edge across which it had for years peered uncertainly out to sea. The problem of petroleum resources on the continental shelf challenges first the geologist, then the engineer. The geologist's immediate and pressing responsibility is to review his accumulated knowledge of the character of the continental shelf, and in the light of his concepts of the origin and occurrence of petroleum, to measure the adequacy of the reward which awaits the conquest of petroleum under the submerged margins of the continents to compensate the risk, effort, and expense which this task poses for the engineer. In reply to this challenge to geologists, it is submitted that if the earth is viewed as a functioning organism, surely one of its normal functions since life covered its surface has been the generation of petroleum, much greater volumes of petroleum than are now believed to exist beneath the land areas of the earth should have been formed through the ages. The most likely place to search for these possible additional stores of petroleum is the continental shelf.

14. "Geology of Basement Complex, Edison Oil Field, Kern County, California," J. H. BEACH, Independent Exploration Company, Bakersfield, and HARRY CAMPBELL, Jergins Oil Company, Bakersfield.

The pre-Tertiary metamorphics in the Edison oil field have, since the discovery of this zone by H. H. Magee in June, 1945, yielded 3,330,000 barrels of oil to August 31, 1946. Of the one hundred and three wells which have since been drilled into the basement during its development, all but six have been completed as commercial producers.

Oil has accumulated within the metamorphics in approximately the same area that contains oil in the overlying sediments. The oil produced from the basement is similar to that of the oil produced from the sands, although gravities vary greatly.

Wells with highest initial potentials and highest productivity indices are those completed in the hard, fresh fractured rocks on locally developed structural highs on the Edison uplift.

15. "Santiago Pool, Kern County, California," GLENN W. LEDINGHAM, Western Gulf Oil Company, Bakersfield.

The Santiago pool is located in Secs. 21 and 22, T. 11 N., R. 23 W., in the south San Joaquin Valley. The initial completion was on August 1, 1945, and since that time 26 producers and 4 dry holes have been drilled.

Production was established from an upper Miocene sand roughly equivalent in age to the basal part of the Stevens sand. The average dip is 70°. The developed portion of the pool is 1½ miles long with a maximum width of 500 feet. The north, south, and west limits have been established and development is continuing easterly.

16. "Ramona Field, Los Angeles and Ventura Counties, California," LOYAL E. NELSON, consulting geologist, Los Angeles.

The Ramona field is located 45 miles northwest of Los Angeles near Castaic Junction in the Santa Clara River Basin, Sec. 18, T. 4 N., R. 17 W., and Sec. 13, T. 4 N., R. 18 W.

Discovery was effected by The Texas Company's Kern 42-18, completed on April 19, 1945, from 150 feet of upper Miocene sand at 3,000 feet, flowing 196 barrels per day 29.3°. Twenty-four wells have been completed since discovery with initial rates ranging from 50 to 150 barrels per day.

The structure is a northeast trending and plunging anticline with north flank cut by the parallel Holser thrust fault of 4,000-5,000 feet throw. Present development has proved an area $\frac{1}{4}$ mile wide by $1\frac{1}{2}$ miles in length.

17. "Stratigraphic and Structural Features of the Ivanpah Quadrangle, Southeastern California," D. F. HEWETT, United States Geological Survey, Washington, D. C.

The following conclusions concerning this area of about 3,800 square miles in southeastern California, are based upon about 25 months field work between 1921 and 1934. The region records almost uninterrupted sedimentation during Paleozoic and Mesozoic time. Before this, there was a sedimentation (Pahrump series about 5,000 feet thick) and this rested upon a crystalline basement (Archean). The Tertiary record of sedimentation and volcanism appears to be wholly late Miocene or early Pliocene. Two major orogenies are recorded by thrust faults and normal faults. The first (Laramide late Cretaceous or early Tertiary) includes at least five major thrust faults along which early Paleozoic rocks generally rest upon upper Paleozoic or early Mesozoic rocks. Great masses of quartz-monzonite were intruded toward the close of the epoch and there was widespread mineralization. It was followed by profound erosion from early Eocene to upper Miocene time. The second orogeny (early Pliocene) followed a period of Mid-Tertiary sedimentation and volcanism. It is represented by a single great thrust fault, remnants of the upper plate of which have been mapped over an area of 20 by 30 miles. It was followed by normal faults and local sedimentation.

NEW ROCK-COLOR CHART FOR FIELD USE

A committee representing a number of geological societies and organizations has begun work on a new rock-color chart designed specifically for field use. The membership of the committee is as follows.

Parker D. Trask, representing the Geological Society of America

Ronald K. DeFord, representing the American Association of Petroleum Geologists

Joseph T. Singewald, Jr., and R. M. Overbeck, representing the Association of American State Geologists

Olaf N. Rove, representing the Society of Economic Geologists

E. N. Goddard, representing the United States Geological Survey

The first meeting of the committee was held on May 2, 1946, in Washington, D. C. Hugh D. Miser, of the Geological Survey, who had been instrumental in getting the work started, gave a brief account of the discussions and correspondence that led up to the organization of the committee. Ronald K. DeFord, who was unable to attend, sent a letter suggesting a general plan of procedure, and this letter was used as a basis for discussion. The following plans were agreed upon by the committee.

1. The rock-color chart is to be based on the Munsell color system, the most widely accepted system of color identification in the United States.

2. Simple color names of the ISCC-NBS (Inter-Society Color Council-National Bureau of Standards) method are to be used on the chart, insofar as is applicable to field use. This method has already been adopted by a large number of societies and organizations interested in color.

3. In addition to the color names, the Munsell hue, value, and chrome designations are to be put on the chart, for the use of any geologists who feel the need of numerical designations and fine color distinctions.

4. Sedimentary, igneous, and metamorphic rocks (both consolidated and unconsolidated) are to be included, and also well cuttings. If possible, both wet and dry rocks are to be included.

The committee is now engaged in collecting and classifying the widest possible range of rock specimens in order to determine the range of colors needed on the chart. The next meeting of the committee is to be held at the Chicago meetings of the Geological Society of America in December, 1946, and at that time, the following problems will be considered.

1. The number and range of colors, and the appropriate names to be used on the chart
2. The shape, size, and arrangement of the chart, the size of the color tabs, and whether holes in the chart should be used to facilitate comparisons with rock samples
3. The method and means of printing and distributing the chart

The committee will welcome any suggestions. The Munsell color system, as applied to rock colors, is discussed by DeFord—"Rock Colors," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 28, No. 1 (January, 1944), pp. 128-37. The ISCC-NBS method of naming colors is described by Dean B. Judd and Kenneth L. Kelly, "Method of Designating Colors," *Nat. Bur. Standards Research Paper 1239* (September, 1939).

AT HOME AND ABROAD

T. L. TAPP is associated with Bennett and Sorrels, independent oil producers, and may be addressed at 2111 North Aydelotte, University Station, Shawnee, Oklahoma.

F. W. MUELLER has resigned from his position as district geologist with the Skelly Oil Company, Houston, Texas, and has joined P. R. Rutherford as geologist.

JAMES S. KAUFFMAN, formerly with the Wilcox Oil Company, Tulsa, Oklahoma, is now with the Sinclair Prairie Oil Company in Tulsa.

J. L. KALB, as assistant manager of the Tropical Oil Company in Colombia, has recently returned to Bogota following a business interlude in the United States and Canada. He is a former director and vice-president of the Creole Petroleum Corporation.

GEORGE M. CUNNINGHAM has been appointed manager of a new exploration department recently organized by the Standard Oil Company of California. Other members of the new department include W. S. W. KEW, chief geologist; S. H. GESTER and W. F. BARBAT, assistant chief geologists; G. C. GESTER, consulting geologist; PHILLIP P. GABY, consulting geophysicist; and W. P. WINHAM, G. L. KNOX, and A. J. SOLARI as district superintendents of exploration.

HARRY H. ARNOLD, JR., has been appointed assistant manager of the Oklahoma-Kansas-Illinois division of The Texas Company, with headquarters in Tulsa, Oklahoma. Arnold has been general superintendent of the company's operations in Illinois.

H. E. SUMMERFORD is in charge of a new stratigraphic well-logging service, Casper, Wyoming. He was formerly district geologist for Kerr-McGee Oil Industries, Inc.

WALTER E. BELT, JR., has opened a consulting geological office in Houston, Texas. He recently resigned as geologist for the Southern Natural Gas Company, Jackson, Mississippi.

GLENN E. CRAYS has left the Texas Pacific Coal and Oil Company, Midland, Texas, and has accepted a position with the Creole Petroleum Corporation, Caracas, Venezuela.

J. BRIAN EBY, consulting geologist of Houston, Texas, recently toured war-torn Europe as a special editorial representative of the *Oil Weekly*. Two articles in the November 4 issue of this publication (Vol. 123, No. 10, pp. 8-17, and 28, 35) are based on these first-hand studies: "Austria's Critical Petroleum Situation," and "Oil at the Peace Conference."

ALBERT J. INGHAM, who has been with Shell Oil Company, Inc., for the past 7 years, has accepted a position as assistant geologist with the Pennsylvania Bureau of Topographic and Geological Survey.

AT HOME AND ABROAD

CURRENT NEWS AND PERSONAL ITEMS OF THE PROFESSION

MARIA SPENCER is now working in Nassau, Bahamas, for the Bahamas Oil Company, Ltd.

Commander RICHARD H. PENCE, U.S.N.R., is now on terminal leave and may be addressed: 3554 Carlin Avenue, Lynwood, California. Before the war he was with the Central Committee California Crude Oil Producers.

J. P. Fox has been elected to the board of directors of the Standard Oil Company of Texas.

JOHN HUBERT BUEHNER is out of the Army and working in the geological department of the Ohio Oil Company at Marshall, Illinois.

KENNETH C. ANDERSON and CHARLES R. GRICE are working in the geological laboratory of the Standard Oil Company of Texas at Midland, Texas.

PAUL H. DUDLEY, formerly of Long Beach, California, may be addressed in care of American Placers, Inc., 107 North 34th Street, Billings, Montana.

C. L. McNULTY, JR., has resigned from the faculty of the department of geology at Southern Methodist University, Dallas, Texas, and has accepted appointment as associate professor of geology, North Texas Agricultural College, Arlington, Texas.

W. HARLAN TAYLOR has announced that he is entering the field of consulting and contracting geophysical service and has established the Taylor Geophysical Company. Headquarters of the company are temporarily situated at 1601 South Shepard Drive, Houston 6, Texas. During the past 13 years Taylor has been associated with the Petty Geophysical Engineering Company.

CLEMENTE GONZÁLES DE JUANA has resigned as consulting geologist to the Instituto Nacional de Obras Sanitarias (Venezuelan Government) to become professor of geology at the University of Caracas. He will teach petroleum geology and the geology of Venezuela. His new address is Apartado 1554, Caracas, Venezuela.

RUSKIN H. MEYER is employed by the Republic Natural Gas Company, 1155 First National Bank Building, Oklahoma City, Oklahoma.

CLIFFORD N. HOLMES, formerly with the U. S. Geological Survey, Baton Rouge, Louisiana, may be addressed in care of the department of geology of Yale University, New Haven, Connecticut.

HOLLIS D. HEDBERG, after 20 years spent in Venezuela, has been transferred to the New York office of the Gulf Oil Corporation, 17 Battery Place, New York City.

R. B. WHEELER has been transferred from Colombia to Venezuela, where his new address is: The Texas Company, Apartado 267, Caracas, Venezuela.

GLEN M. RUBY, of Hoover, Curtice & Ruby, Inc., New York, is in Cuba for a couple of months, after which he expects to spend most of his time on his Iowa farm, although he is not "laying down the pick to pick up the plow, but will keep one in each hand." Some months ago he took time from his oil-discovery work at Punta Arenas, Chile, to visit the Far East.

W. S. HOFFMEISTER, geologist for several years with the Carter Oil Company at Shreveport, Louisiana, has been transferred to the Carter Research Laboratory at Tulsa, Oklahoma.

Colonel O. F. KOTICK has been released from leave-of-absence status with the Tide Water Associated Oil Company in California and has joined the Regular Army, with the permanent rank of Major. His address is The Joint Chiefs of Staff, Army-Navy Petroleum Board, 2830 Navy Building, Washington 25, D. C.

The Rocky Mountain Association of Petroleum Geologists met, October 28, in the Empire Room of the Shirley-Savoy Hotel, Denver, Colorado. J. HARLAN JOHNSON spoke on the San Carlos Mountains of Chihuahua, illustrating his talk with color slides.

Meeting in the South American Room, Rice Hotel, Houston, Texas, on October 28, the Houston Geological Society heard FRED W. BATES speak on the "Geology of West Tepetate Oil Field, Jefferson Davis Parish, Louisiana."

KATHARINE W. CARMAN has resigned from her position as district geologist for the Great Lakes Carbon Corporation in the Illinois district.

Speaking before the Shawnee (Oklahoma) Geological Society, meeting in the Aldridge Hotel, Shawnee, on October 10, JACK DAVIES described the "Canol Project" and illustrated his talk with colored motion pictures.

HARRY H. POWER, in his article entitled "Petroleum Highlights in Venezuela," published in the October issue of the *Petroleum Engineer*, reports on his recent visit to South America.

HENRY KEPLINGER, of the consulting firm of Keplinger and Wanenmacher, Tulsa, Oklahoma, spoke on September 25 before the Oklahoma Society of Petroleum Engineers, Oklahoma City, on the subject "Appraisal of Oil Producing Properties." JOSEPH M. WANENMACHER, of the same firm, spoke on October 8 in Wichita Falls, Texas, before the North Texas Chapter of the American Petroleum Institute. The subject of his address: "Geology and Engineering Problems of the Hull Silk Field, North Texas."

M. G. CHENEY, Coleman, Texas, and J. V. HOWELL, Tulsa, Oklahoma, participated in the annual meeting of the Independent Petroleum Association of America held at Fort Worth, Texas, October 28-30. Howell addressed the meeting on the subject of "Known and Potential Sources of Supply of Petroleum in the United States." Cheney, past-president of the A.A.P.G., was one of a panel of experts who participated in a discussion of national oil policy.

JOSEPH L. BORDEN, geologist for many years at the Tulsa, Oklahoma, office of the Pure Oil Company, has been transferred to Durango, Colorado, where he has opened an office for the company.

V. ELVERT MONNETT, director of the School of Geology, University of Oklahoma, spoke at a recent meeting of the oil and gas division of Oklahoma City Chamber of Commerce. His subject: "The History and Future of Oil Development in Oklahoma."

HAROLD W. HOOTS has returned to his consulting office in Los Angeles, California, after spending several weeks in South America studying the geology of Peru.

EMMETT A. FINLEY, formerly employed in Jackson, Mississippi, by the Magnolia Petroleum Company, is now engaged as a field geologist for the Creole Petroleum Corporation in Caracas, Venezuela.

CARL A. MOORE, associate professor of geology at the University of Oklahoma, addressed the Oklahoma City Geological Society at a special noon luncheon on Tuesday, October 15. His subject was "The South Moore Oil Field, Cleveland County, Oklahoma."

BURTON W. COLLINS is a geologist with the New Zealand Geological Survey, 156 The Terrace, Wellington, New Zealand. Previous connections include the Island Exploration Company, New Guinea in 1937 and 1938; the New Zealand Petroleum Company in 1938-1942; and the Dominion Compressed Yeast Company, Auckland, since 1942.

LEO HENDRICKS, who has been a member of the staff of the Bureau of Economic Geology, Austin, Texas, since 1937, has resigned to join the faculty of Texas Christian University.

CEVAT EYÜP TAŞMAN of Ankora, Turkey, now holds the position of chief petroleum adviser in the M. T. A. Institute.

ROBERT W. LANGE has left Amerada Petroleum Corporation and has opened a consulting office at 108 Grand Street, Garden City, Kansas.

JACK GARDNER has resigned his position with Gulf Oil Corporation to accept a position with the Photographic Intelligence Center, U. S. Navy Receiving Station, Washington 25, D. C.

M. F. PRYOR has opened an office as a consulting geologist at his home in Great Bend, Kansas.

F. E. METTNER has resigned from the Sunray Oil Company and has returned to his home in Wichita, Kansas.

KILBURN E. ADAMS, JR., has succeeded W. M. Guthrey as Kansas district geologist, at Wichita, for The Texas Company. Guthrey has been transferred to the Tulsa office.

BEN HURLBUTT and FRANK HERRING announce the formation of Ben-Franklin Exploration, Inc., specializing in core drilling. They are located at 805 Petroleum Building, Wichita, Kansas.

JACK H. HEATHMAN is vice-president of the H. H. & B. Drilling Co., Inc., 700 Petroleum Bldg., Wichita, Kansas.

DAN E. BOONE, Halliburton Oil Well Cementing Company, Duncan, Oklahoma, spoke on "Portable Electric Logging Equipment" at the luncheon meeting of the Tulsa Geological Society on November 8.

K. R. PARSONS has moved to Stanford University, where his new address is Building 312, Stanford Village, Stanford University, California.

E. A. McCULLOUGH, formerly with the Phillips Petroleum Company, Midland, Texas, is now with the Sunray Oil Corporation, Box 941, Midland, Texas.

FREDERICK T. HOLDEN is now district geologist in Mississippi and Alabama for the Carter Oil Company. Formerly in Shreveport, Louisiana, he may now be addressed at Box 1490, Jackson, Mississippi.

K. F. HUFF, International Petroleum Company, Ltd., has moved from Guayaquil, Ecuador, to Lima, Peru, where his address is Box 1081.

JOHN A. YOUNG, JR., has left the Sun Oil Company to accept appointment as assistant professor of geology at Syracuse University, Syracuse, New York.

JOHN J. RUPNIK, formerly with the Sun Oil Company, Beaumont, Texas, has accepted a position as geophysicist with the Sinclair Prairie Oil Company, Box 521, Tulsa 5, Oklahoma.

EUGENE F. BOEHMS, recently district geologist for the American Trading and Production Corporation, Abilene, Texas, is now associated with the Woodley Petroleum Company, 712 Alexander Building, Abilene.

Major LOUIS DeGOES is overseas with the AAF Air Transport Command. His address is 1500th AAFBU-P.D.-A.T.C., APO 953, c/o P.M., San Francisco, California.

NORMAN C. SMITH has moved from Somerville, New Jersey, to Tallahassee, Florida, where he is employed by the Humble Oil and Refining Company.

ERNST KUNDIG, formerly of Lima, Peru, may now be addressed: Bataafsche Petroleum Mij., Carel van Bijlandslaan, The Hague, Holland.

J. R. REEVES is now with the Lee Geophysical Exploration and Research Corporation, Box 632, Cisco, Texas. He was formerly with the National Geophysical Company, Dallas, Texas.

DAVID K. LANGFORD has a consulting geological office at 627 Hamilton Building, Wichita Falls, Texas.

REAGAN TUCKER has moved from Corpus Christi to San Antonio, Texas, where he has a consulting geological office at 528 Milam Building.

FRANK W. ROHWER, formerly with the Pioneer Oil Corporation, is now an independent consulting geologist, and may be addressed at 1433 Pine Street, Boulder, Colorado.

KENDALL E. BORN, for many years a member of the State Division of Geology, Nashville, Tennessee, has resigned to accept an assistant professorship in the department of geology at the School of Mines and Metallurgy, Rolla, Missouri.

DOUGLAS D. HOWARD is doing petroleum geological work in South America, having recently joined the staff of the Creole Petroleum Corporation, Apartado 172, Maracaibo, Venezuela.

J. R. LOCKETT of the Ohio Fuel Gas Company, Columbus, Ohio, spoke before the Appalachian Geological Society on October 13, in Charleston, West Virginia, on "The Development of Structure in the Basin Areas of Northeastern United States."

CARL T. ANDERSON, formerly an independent of Wichita Falls, Texas, has taken charge of the Republic Natural Gas Company office in Oklahoma City, Oklahoma.

J. C. HEGGBLOM may be addressed in care of the Bahamas Exploration Company, Ltd., Nassau, Bahamas, B.W.I.

THOMAS C. WILSON has completed a three-month vacation in the United States and is now back with the Venezuelan Atlantic Refining Company, Apartado 893, Caracas, Venezuela.

FRANCIS A. HALE has left Geophysical Service, Inc., Dallas, Texas, in order to accept a position as seismologist with the Richmond Exploration Company, Sociedad a Camejo 16, Caracas, Venezuela.

B. B. BRADISH may be addressed in care of the Tropical Oil Company, Bogota, Colombia.

INDEX OF VOLUME 30 (1946)

Abstracts, Application of Geology to Military Science and Special Papers	740
Abstracts of Biloxi Meeting, October 24-25	1903
—, of Papers on Technical Program. The Association Round Table	740
—, Pacific Section Twenty-Second Annual Meeting, November 8 and 9, 1945. The Association Round Table	128
Abstracts, Pacific Section	2087
—, Papers "by Title"	751
—, Regional and Oil-Field Papers	749
—, Tectonics and Oil-Field Papers	745
—, Trends and Developments since 1941	747
Accumulation of Oil in Continental Sediments at the South Belridge Oil Field, Kern County, California. By E. J. Coenen and H. D. Hobson. Abstract	2090
Activities, Expanding, of Paleontologists. By John R. Sandidge	1088
Aerial Photography, Some Developments in, during the War. Geological Note by L. E. Nugent, Jr.	725
Age of Penters Chert, Batesville District, Arkansas. Geological Note by Douglas M. Kinney	611
Agnew, Allen F., and Heyl, Allen V., Jr. Quimbys Mill, New Member of Plattville Formation, Mississippi Valley. Geological Note	1585
Ahlfeld, F. Geologia de Bolivia. Review by Norman D. Newell	2065
Alabama Coastal Plain, Vick Formation of Pre-Tuscaloosa Age of. Geological Note by Louis C. Conant	711
Alabama, Western, Pre-Selma Upper Cretaceous Stratigraphy of. By Watson H. Monroe, Louis C. Conant, and D. Hoyer Eargle	187
Alaska, Recent Investigations by United States Geological Survey of Petroleum Possibilities in. By John C. Reed	1433
Alberta and Montana, Fossil Plants and Jurassic-Cretaceous Boundary in. By Roland W. Brown	238
Alexander, C. W. Developments in Southeastern States in 1945	1020
Alexander, C. W., and Harris, R. M. Abstract	1904
Algae Reefs in Cap Rock of Ogallala Formation on Llano Estacado Plateau, New Mexico and Texas. By W. Armstrong Price, Maxim K. Elias, and John C. Frye	1742
Allison, A. P., Beckelhymer, R. L., Benson, Don G., Hutchins, R. M., Jr., Lake, C. L., Lewis, Ray C., O'Bannon, P. H., Self, S. R., and Warner, C. A. Geology of Katy Field, Waller, Harris, and Fort Bend Counties, Texas	157
Alpha-Particle Bombardment, Formation of Hydrocarbons from Fatty Acids by. By C. W. Sheppard and W. L. Whitehead	32
Alunite at Woodbine-Eagle Ford Contact in Northeastern Texas. Geological Note by L. W. Stephenson	1764
Amendments to Constitution and By-Laws. At Home and Abroad	1620
Amendments to Constitution and By-Laws. The Association Round Table	139
American Association of Petroleum Geologists, Association Committees	126, 287, 357, 1057, 1206, 1312, 1597, 1779, 1960,
American Association of Petroleum Geologists. Constitution and By-Laws. The Association Round Table	2071
American Association of Petroleum Geologists Fall Meeting, Biloxi, Mississippi, October 24, 25, 1946. Announcement. The Association Round Table	1600
American Association of Petroleum Geologists, Financial Statement for 1945. The Association Round Table	1314, 1615
American Association of Petroleum Geologists, Financial Statement, Division of Paleontology and Mineralogy, for 1945. The Association Round Table	455
American Association of Petroleum Geologists, Membership List, March 2, 1946. The Association Round Table	459
American Association of Petroleum Geologists Mid-Continent Regional Meeting, Wichita, Kansas, January 16-17, 1947. Announcement. The Association Round Table	361
American Association of Petroleum Geologists, Minutes. Thirty-First Annual Business Meeting, Chicago, April 1-4, 1946. By Edward A. Koester. The Association Round Table	1615, 2078
American Association of Petroleum Geologists, Past and Present Officers. The Association Round Table	755
American Association of Petroleum Geologists, Supplementary Membership List, September 1, 1946. The Association Round Table	360
	1610

American Association of Petroleum Geologists, Thirty-First Annual Meeting, Chicago, April 1-4, 1946. The Association Round Table	738
A.P.I. Research Project No. 43—Transformation of Organic Material into Petroleum, Progress Report on, by G. M. Knebel	1935
Americas, Tectonic Development of, to Form the East Rim of the Pacific. By Hans Stille. Review by W. A. Ver Wiebe	1054
Amsden, Ellis, and Big Snowy Group, Judith Basin, Montana. By Paul T. Walton	1294
Anderson, Frank Marion. Memorial by C. M. Wagner	636
Appalachian Area, Developments in 1945. By Appalachian Geological Society	861
Appalachian Geological Society. Developments in Appalachian Area in 1945	861
Application of Geology to Military Activities. By W. P. T. Hill. Abstract	740
Application of Geology to Military Science and Special Papers. Abstracts	740
Aquitaine Basin, France, Petroleum Geology of. By A. J. Eardley	1517
Archuleta County, Colorado, Gramp's Field. By W. A. Waldschmidt	561
Arellano, Alberto, R. V., and Cooper, G. Arthur. Stratigraphy Near Caborca, Northwest Sonora, Mexico. Geological Note	606
Argentina, Northern, Province of Salta, San Pedro Oil Field. By Lyman C. Reed	591
Arizona, Faulting in East Part of Grand Canyon of. By C. E. Van Gundy	1899
Arizona, Western New Mexico, and Northern New Mexico, Developments in 1945. By Robert L. Bates	958
Arkansas, Age of Penters Chert, Batesville District. Geological Note by Douglas M. Kinney	611
Arkansas, South, and North Louisiana, Developments in 1945. By William S. Hoffmeister and Van Daniel Robinson	1007
Asphaltic Sands Found to Occur in Oil Fields. Geological Note by D. B. Taliaferro and K. E. Stanfield	616
Assistant Business Manager, Elmer W. Ellsworth Appointed. The Association Round Table	1211
At Home and Abroad	147, 297, 470, 640, 807, 1068, 1217, 1318, 1617, 1789, 1973, 2092
Atlantic Coastal Plain Floor and Continental Slope of North Carolina. Geological Note by W. F. Prouty	1917
Attack, The Geological. By M. G. Cheney	1077
Aurin, F. L., chairman. Report of National Service Committee. The Association Round Table	778
Austin County, Texas, Raccoon Bend Salt Dome. Geological Note by H. J. McLellan	1306
Baca, Las Animas, and Otero Counties, Colorado, Correlation of Paleozoic Rocks Across Las Animas Arch in. By John C. Maher	1756
Bailey, Thomas L. Abstract	2089
Ball, Max W., chairman. Report of Committee on Boy Scout Literature. The Association Round Table	785
Barb, Clark F. Selected Well Logs of Colorado. Review	282
Barbat, W. F., and Taliaferro, N. L. Notes on Geology of Deep Coles Levee Well, Kern County, California. Abstract. The Association Round Table	132
Barton County, Northeastern, Central Kansas, Buried Pre-Cambrian Hills in. By Robert F. Walters	660
Bartram, John G. Final Report of Committee on Method of Election of Officers. The Association Round Table	134
Bartram, John G., chairman. Report of Committee on Geologic Names and Correlations. The Association Round Table	790
Bass, N. W., Thomas, C. R., and Huddle, John W. Abstract	749
Bates, Fred W., and Wharton, J. B., Jr. Developments in Gulf Coast of Louisiana in 1945	999
Bates, Fred W., and Wharton, Jay B. Abstract	1966
Bates, Robert L. Abstract	751
Bates, Robert L. Developments in Arizona, Western New Mexico, and Northern New Mexico in 1945	958
Batesville District, Arkansas, Age of Penters Chert. Geological Note by Douglas M. Kinney	611
Beach, Floyd K. Photography of Megafossils. Discussion	620
Beach, J. H., and Campbell, Harry. Abstract	2090
Beck, R. Stanley. Abstract	2088
Benson, Don G., Allison, A. P., Beckelhymer, R. L., Hutchins, R. M., Jr., Lake, C. L., Lewis, Ray C., O'Bannon, P. H., Self, S. R., and Warner, C. A. Geology of Katy Field, Waller, Harris, and Fort Bend Counties, Texas	157
Beckelhymer, R. L. Stratigraphy of Waller and Harris Counties, Texas	52
Beckelhymer, R. L., Allison, A. P., Benson, Don G., Hutchins, R. M., Jr., Lake, C. L., Lewis, Ray C., O'Bannon, P. H., Self, S. R., and Warner, C. A. Geology of Katy Field, Waller,	

Harris, and Fort Bend Counties, Texas	157
Beilharz, Carl F., and Davis, Donald M. Developments in Upper Gulf Coast of Texas in 1945	991
Bell, Alfred H. Developments in Eastern Interior Basin in 1945	879
Bell, John S., Wendlandt, E. A., and Shelby, T. H., Jr., Hawkins Field, Wood County, Texas	1830
Bell, John, Wendlandt, E. A., and Shelby, T. H. Abstract	746
Bibliographies, General, on Geological Material	1326
Big Snowy, Amsden, and Ellis Group, Judith Basin, Montana. By Paul T. Walton	1204
Biloxi Meeting, Abstracts of, October 24-25	1963
Boice Shale, New Mississippian Subsurface Formation in Southeast Nebraska. Geological Note by E. C. Reed	348
Bolivia, <i>Geologia de</i> , by F. Ahlfeld. Review by Norman D. Newell	2065
Books—War Victims. At Home and Abroad	1071
Borden, Joseph L. Developments in Oklahoma in 1945	902
Bornhauser, Max. Abstract	745
Bowen, Gilbert T. Memorial of Kenneth Mason Bravinder	805
Brantly, J. E. Memorial of Harold Kurtz Shearer	1315
Bravinder, Kenneth Mason. Memorial by Gilbert T. Bowen	805
British Guiana, Report on Exploration for Oil in. By H. G. Kugler <i>et al.</i> Review by H. D. Hedberg	120
Broggi, J. A. "Jacob Staff" and Measurements of Stratigraphic Sequences. Geological Note 716,	1934
Brown, Roland W. Fossil Plants and Jurassic-Cretaceous Boundary in Montana and Alberta	238
Bucher, J. E., Woods, E. Hazen, and Chase, C. L. Developments in West Texas and Southeastern New Mexico in 1945	930
Buckley, Stuart E. Abstract	748
Buckley, Stuart E. Trends and Developments in Petroleum Engineering	1131
Buena Vista Hills (27-B Pool). By Evan Burtner. Abstract. The Association Round Table	129
Burger, Robert W. Memorial by Rollin Eckis	803
Buried Pre-Cambrian Hills in Northeastern Barton County, Central Kansas. By Robert F. Walters	660
Burtner, Evan. Buena Vista Hills (27-B Pool). Abstract. The Association Round Table	129
Caborca, Northwest Sonora, Mexico, Stratigraphy Near. Geological Note by G. Arthur Cooper, and Alberto R. V. Arellano	606
California, Developments in 1945. By Graham B. Moody	829
—, Mineralogy of Late Upper Cretaceous, Paleocene, and Eocene Sandstones of Los Banos District, West Border of San Joaquin Valley. By S. N. Daviess	63
—, Puente and San Jose Hills, Miocene Conglomerates of. By A. O. Woodford, T. G. Moran, and J. S. Shelton	514
Cambrian and Ordovician Rocks Penetrated by Recent Wells Drilled in Southeastern Michigan. By George V. Cohee. Abstract	752
Cambrian History of Grand Canyon Region. By Edwin D. McKee and Charles E. Resser. Review	282
Campbell, Harry, and Beach, J. H. Abstract	2090
Canada, Development in 1945. By George S. Hume	851
Cap Rock of Ogallala Formation on Llano Estacado Plateau, New Mexico and Texas, Algae Reefs in. By W. Armstrong Price, Maxim K. Elias, and John C. Frye	1742
Carbonaceous Hydrocarbon: Harbolite. Geological Note by Cevat E. Tasman	1051
Carbonate Rock, Grain Size in. Geological Note by Ronald K. DeFord	1921
Carpathian Region, Oil Fields of. By Ray P. Walters	319
Case Histories, Geological, Publication of. By Henry C. Cortes	1095
Cenozoic Deposits of Mississippi and Adjacent Areas. By Grover E. Murray, Jr. Abstract	1964
Central Kansas. Buried Pre-Cambrian Hills in Northeastern Barton County. By Robert F. Walters	660
—, Siluro-Devonian Strata in. By Hall Taylor	1221
Central Texas, Lower Pennsylvanian Terminology in. By R. C. Spivey and T. G. Roberts	181
Chase, C. L., Woods, E. Hazen, and Bucher, J. E. Developments in West Texas and Southeastern New Mexico in 1945	930
Cheney, M. G. Elias Howard Sellards—Honorary Member. The Association Round Table	735
—, Report of President. The Association Round Table	761
—, representative. Report of Representative on Division of Geology and Geography of National Research Council, 1945-1946. The Association Round Table	792
—, The Geological Attack	1077
Chisholm, William Francis. Memorial by G. D. Thomas	1213
Clark, Bruce Lawrence. Memorial by Chester Stock	1065

Clark, Frank R. Recipient of President's Award—Horace Gardiner Richards. The Association Round Table	736
—, chairman. Report of Medal Award Committee. The Association Round Table	785
Clark, Frank R., chairman. Report of the Nominating Committee. The Association Round Table	1609
Clark, Robert W., chairman. Minutes of Business Committee. The Association Round Table	794
—, chairman. Report of Business Committee. The Association Round Table	757
Classification of Oil Possibilities, Outline for. Geological Note by Frank Reeves	111
Clements, Thomas. Stratigraphic Section East of Bogota, Colombia. Abstract. The Association Round Table	130
Coenen, E. J., and Hobson, H. D. Abstract	2090
Coffin, R. Clare. Abstract	748
Cohce, George V. Abstract	752
Cole, Virgil B., and Koester, Edward A. Developments in North Mid-Continent in 1945	895
Collection of Drill Cuttings, West Virginia Geological Survey. Geological Note by James H. C. Martens	350
College Students Majoring in Geology, Survey of. Research Note by A. I. Levorsen	730
Colorado, Archuleta County, Gramp's Field. By W. A. Waldschmidt	561
—, Selected Well Logs of. By Clark F. Barb. Review	282
Comparative Data of Membership. The Association Round Table	767
Conant, Louis C. Vick Formation of Pre-Tuscaloosa Age of Alabama Coastal Plain. Geological Note	711
Conant, Louis C., Monroe, Watson H., and Eargle, D. Hoyer. Pre-Selma Upper Cretaceous Stratigraphy of Western Alabama	187
Conodonts as Paleozoic Guide Fossils. By Samuel P. Ellison, Jr.	93
—, from Triassic of Sinai (Egypt). Geological Note by D. B. Eicher	613
Continental Shelves, Origin of. By J. H. F. Umbgrove	249
Constitution and By-Laws. The Association Round Table	1600
Continental Slope of North Carolina, Atlantic Coastal Plain Floor and. Geological Note by W. F. Prouty	1917
Continents and Oceans, Distribution of. By W. G. Woolnough	1981
Conway, William Palen, Jr. Memorial by M. H. Steig	403
Cooke, S. R. B., and Sloss, L. L. Abstract	749
—, Spectrochemical Sample Logging of	1888
Cooper, G. Arthur, and Arellano, Alberto, R. V. Stratigraphy Near Caborca, Northwest Sonora, Mexico. Geological Note	606
Correlation of Permian of West Texas and Southeast New Mexico. By John W. Skinner	1857
—, of Paleozoic Rocks across Las Animas Arch in Baca, Las Animas, and Otero Counties, Colorado. By John C. Maher	1756
Correlations Committee, Geologic Names and, Functions and Organization of. By Henry J. Morgan, Jr. The Association Round Table	2079
Cortes, Henry C. Publication of Geological Case Histories	1095
Cox, Ben B. Transformation of Organic Material into Petroleum under Geological Conditions (The Geological Fence)	645
Craig, Eric K. Memorial of Donald Dudley Hughes	1786
Cranfield Field, Adams and Franklin Counties, Mississippi. By George Zebal. Abstract	1967
Cretaceous, Late Upper, Paleocene, and Eocene Sandstones of Los Banos District, West Border of San Joaquin Valley, California, Mineralogy of. By S. N. Daviess	63
—, of Colombia. By J. Wyatt Durham. Abstract	2089
—, Upper, and Paleocene in Western Ecuador, Micropaleontology of. By Hans E. Thalmann	337
—, Upper, Pre-Selma, Stratigraphy of Western Alabama. By Watson H. Monroe, Louis C. Conant, and D. Hoyer Eargle	187
Crider, Albert Foster. Memorial by C. L. Moody	633
Croneis, Carey. Science Legislation and Geology	1104
Current, A. M. Abstract	1967
Dating Sedimentation, Vulcanism, and Orogeny by Heavy Minerals in Beartooth Region, Montana. By Marcellus H. Stow. Abstract	751
David, Max. Devonian (?) Producing Zone, TXL Pool, Ector County, Texas. Geological Note	118
Davis, Donald M., and Beilharz, Carl F. Developments in Upper Gulf Coast of Texas in 1945	991
Daviess, S. N. Mineralogy of Late Upper Cretaceous, Paleocene, and Eocene Sandstones of Los Banos District, West Border of San Joaquin Valley, California	63

Deferment of Scientific and Technical Personnel. Office of Scientific Personnel, Bulletin 26.	
By M. H. Trytten. The Association Round Table	141
DeFord, Ronald K. Grain Size in Carbonate Rock. Geological Note	1921
— Review of A Survey of Weathering Processes and Products, by Parry Reiche	280
DeFord, Ronald K., and Waldschmidt, W. A. Oölite and Oöolith. Geological Note	1587
Delhi, West Delhi and Big Creek Fields. By A. M. Lloyd and R. B. Totten. Abstract	1967
Denison, A. Rodger. The Geologist in World War II—A Memorial	802
Development in Canada in 1945. By George S. Hume	851
— in South Texas in 1945. By Bruce Scrafford	972
— of Structures in Basin Areas of Northeastern United States. By J. R. Lockett. Abstract	743
—, Tectonic, of the Americas to Form the East Rim of the Pacific. By Hans Stille. Review by W. A. Ver Wiebe	1054
Developments in Appalachian Area in 1945. By Appalachian Geological Society	861
— in Arizona, Western New Mexico, and Northern New Mexico in 1945. By Robert L. Bates	958
— in California in 1945. By Graham B. Moody	829
— in East Texas during 1945. By T. H. Shelby, Jr., and G. J. Loetterle	980
— in Eastern Interior Basin in 1945. By Alfred H. Bell	879
— in Louisiana Gulf Coast in 1945. By Fred W. Bates and Jay B. Wharton, Jr.	999
— in Michigan in 1945. By H. J. Hardenberg	886
— in North Mid-Continent in 1945. By Virgil B. Cole and Edward A. Koester	895
— in North and West-Central Texas in 1945. By North Texas Geological Society	963
— in Oklahoma in 1945. By Joseph L. Borden	902
— in South Arkansas and North Louisiana in 1945. By William S. Hoffmeister and Van Daniel Robinson	1007
— in Rocky Mountain Region in 1945. By E. W. Krampert	912
— in Southeastern States in 1945. By C. W. Alexander	1020
— in Texas Panhandle in 1945. By Porter A. Montgomery, Jr., and Le Roy Fugitt	925
— in Upper Gulf Coast of Texas in 1945. By Donald M. Davis and Carl F. Beilharz	991
— in West Texas and Southeastern New Mexico in 1945. By E. Hazen Woods, C. L. Chase, and J. E. Bucher	930
Developments and Trends in Petroleum Engineering. By Stuart E. Buckley	1131
Devonian (?) Producing Zone, TXL Pool, Ector County, Texas. Geological Note by Max David	118
Devonian-Siluro Strata in Central Kansas. By Hall Taylor	1221
Devonian Stratigraphy in Montana. By Wilson M. Laird and Laurence L. Sloss. Abstract	751
Diastrophic Activity, During Historic Time, in Western Gulf Coastal Plain. By Martin M. Sheets. Abstract	745
Dickerson, Roy E., and Straley, H. W., III. Suggestions for Naming Multiple Sands. Geological Note	115
Dickey, Parke A. Distinguished Lecture Tour. At Home and Abroad	301
Directory of Geological Material in North America. By J. V. Howell and A. I. Levorsen	1321
— Bibliographies, General	1326
— Canada, by Provinces, and Newfoundland	1337
— Central American Countries	1347
— Commercial Map Publishers	1330
— Dictionaries, Glossaries, Encyclopedias, Statistics, and Handbooks	1327
— Foreword. By J. V. Howell and A. I. Levorsen	1322
— General Material:—National and Continental in Area	1323
— Libraries Furnishing Photostat and Microfilm Service	1334
— Mexico	1348
— Miscellaneous Books and Publications of General Geological Interest	1328
— Publications and Non-Commercial Publishing Agencies, Regional, National, and Continental	1323
— Regional and National Geologic and Physiographic Maps	1331
— Specific Material:—State and Province in Area	1337
— State and Province Geological Maps	1332
— Thin-Section and Rock-Polishing Service	1336
— Trade Journals: Oil, Gas, Mineral Industry	1334
— United States—States and Territories	1349
Discussion	275, 620, 1053, 1589, 2035
Distinguished Lecture by T. S. Oakwood. At Home and Abroad	476
Distinguished Lecture Tour by Parke A. Dickey. At Home and Abroad	301
— by Paul H. Price. At Home and Abroad	1976
— by H. N. Fisk	2041

Clark, Frank R. Recipient of President's Award—Horace Gardiner Richards. The Association Round Table	736
—, chairman. Report of Medal Award Committee. The Association Round Table	785
Clark, Frank R., chairman. Report of the Nominating Committee. The Association Round Table	1609
Clark, Robert W., chairman. Minutes of Business Committee. The Association Round Table	794
—, chairman. Report of Business Committee. The Association Round Table	757
Classification of Oil Possibilities, Outline for. Geological Note by Frank Reeves	111
Clements, Thomas. Stratigraphic Section East of Bogota, Colombia. Abstract. The Association Round Table	130
Coenen, E. J., and Hobson, H. D. Abstract	2090
Coffin, R. Clare. Abstract	748
Cohee, George V. Abstract	752
Cole, Virgil B., and Koester, Edward A. Developments in North Mid-Continent in 1945	895
Collection of Drill Cuttings, West Virginia Geological Survey. Geological Note by James H. C. Martens	350
College Students Majoring in Geology, Survey of. Research Note by A. I. Levorsen	730
Colorado, Archuleta County, Gramp's Field. By W. A. Waldschmidt	561
—, Selected Well Logs of. By Clark F. Barb. Review	282
Comparative Data of Membership. The Association Round Table	767
Conant, Louis C. Vick Formation of Pre-Tuscaloosa Age of Alabama Coastal Plain. Geological Note	711
Conant, Louis C., Monroe, Watson H., and Earle, D. Hoyer. Pre-Selma Upper Cretaceous Stratigraphy of Western Alabama	187
Conodonts as Paleozoic Guide Fossils. By Samuel P. Ellison, Jr.	93
—, from Triassic of Sinai (Egypt). Geological Note by D. B. Eichler	613
Continental Shelves, Origin of. By J. H. F. Umbgrove	249
Constitution and By-Laws. The Association Round Table	1600
Continental Slope of North Carolina, Atlantic Coastal Plain Floor and. Geological Note by W. F. Prouty	1917
Continents and Oceans, Distribution of. By W. G. Woolnough	1981
Conway, William Palen, Jr. Memorial by M. H. Steig	463
Cooke, S. R. B., and Sloss, L. L. Abstract	749
—, Spectrochemical Sample Logging of	1888
Cooper, G. Arthur, and Arellano, Alberto, P. V. Stratigraphy Near Caborca, Northwest Sonora, Mexico. Geological Note	606
Correlation of Permian of West Texas and Southeast New Mexico. By John W. Skinner	1857
—, of Paleozoic Rocks across Las Animas Arch in Baca, Las Animas, and Otero Counties, Colorado. By John C. Maher	1756
Correlations Committee, Geologic Names and, Functions and Organization of. By Henry J. Morgan, Jr. The Association Round Table	2079
Cortes, Henry C. Publication of Geological Case Histories	1095
Cox, Ben B. Transformation of Organic Material into Petroleum under Geological Conditions (The Geological Fence)	645
Craig, Eric K. Memorial of Donald Dudley Hughes	1786
Cranfield Field, Adams and Franklin Counties, Mississippi. By George Zebal. Abstract	1967
Cretaceous, Late Upper, Paleocene, and Eocene Sandstones of Los Banos District, West Border of San Joaquin Valley, California, Mineralogy of. By S. N. Daviess	63
—, of Colombia. By J. Wyatt Durham. Abstract	2089
—, Upper, and Paleocene in Western Ecuador, Micropaleontology of. By Hans E. Thalmann	337
—, Upper, Pre-Selma, Stratigraphy of Western Alabama. By Watson H. Monroe, Louis C. Conant, and D. Hoyer Earle	187
Crider, Albert Foster. Memorial by C. L. Moody	633
Cronis, Carey. Science Legislation and Geology	1104
Current, A. M. Abstract	1967
Dating Sedimentation, Vulcanism, and Orogeny by Heavy Minerals in Beartooth Region, Montana. By Marcellus H. Stow. Abstract	751
David, Max. Devonian (?) Producing Zone, TXL Pool, Ector County, Texas. Geological Note	118
Davis, Donald M., and Beilharz, Carl F. Developments in Upper Gulf Coast of Texas in 1945	991
Daviess, S. N. Mineralogy of Late Upper Cretaceous, Paleocene, and Eocene Sandstones of Los Banos District, West Border of San Joaquin Valley, California	63

Deferment of Scientific and Technical Personnel. Office of Scientific Personnel, Bulletin 26.	
By M. H. Trytten. The Association Round Table	141
DeFord, Ronald K. Grain Size in Carbonate Rock. Geological Note	1921
—, Review of A Survey of Weathering Processes and Products, by Parry Reiche	280
DeFord, Ronald K., and Waldschmidt, W. A. Oolite and Oolith. Geological Note	1587
Delhi, West Delhi and Big Creek Fields. By A. M. Lloyd and R. B. Totten. Abstract	1967
Denison, A. Rodger. The Geologist in World War II—A Memorial	802
Development in Canada in 1945. By George S. Hume	851
— in South Texas in 1945. By Bruce Scrafford	972
— of Structures in Basin Areas of Northeastern United States. By J. R. Lockett. Abstract	743
—, Tectonic, of the Americas to Form the East Rim of the Pacific. By Hans Stille. Review by W. A. Ver Wiebe	1054
Developments in Appalachian Area in 1945. By Appalachian Geological Society	861
— in Arizona, Western New Mexico, and Northern New Mexico in 1945. By Robert L. Bates	958
— in California in 1945. By Graham B. Moody	829
— in East Texas during 1945. By T. H. Shelby, Jr., and G. J. Loetterle	980
— in Eastern Interior Basin in 1945. By Alfred H. Bell	879
— in Louisiana Gulf Coast in 1945. By Fred W. Bates and Jay B. Wharton, Jr.	909
— in Michigan in 1945. By H. J. Hardenberg	886
— in North Mid-Continent in 1945. By Virgil B. Cole and Edward A. Koester	895
— in North and West-Central Texas in 1945. By North Texas Geological Society	963
— in Oklahoma in 1945. By Joseph L. Borden	902
— in South Arkansas and North Louisiana in 1945. By William S. Hoffmeister and Van Daniel Robinson	1007
— in Rocky Mountain Region in 1945. By E. W. Krampert	912
— in Southeastern States in 1945. By C. W. Alexander	1020
— in Texas Panhandle in 1945. By Porter A. Montgomery, Jr., and Le Roy Fugitt	925
— in Upper Gulf Coast of Texas in 1945. By Donald M. Davis and Carl F. Beilharz	991
— in West Texas and Southeastern New Mexico in 1945. By E. Hazen Woods, C. L. Chase, and J. E. Bucher	930
Developments and Trends in Petroleum Engineering. By Stuart E. Buckley	1131
Devonian (?) Producing Zone, TXL Pool, Ector County, Texas. Geological Note by Max David	118
Devonian-Siluro Strata in Central Kansas. By Hall Taylor	1221
Devonian Stratigraphy in Montana. By Wilson M. Laird and Laurence L. Sloss. Abstract	751
Diastrophic Activity, During Historic Time, in Western Gulf Coastal Plain. By Martin M. Sheets. Abstract	745
Dickerson, Roy E., and Straley, H. W., III. Suggestions for Naming Multiple Sands. Geological Note	115
Dickey, Parke A. Distinguished Lecture Tour. At Home and Abroad	301
Directory of Geological Material in North America. By J. V. Howell and A. I. Levorsen	1321
— Bibliographies, General	1326
— Canada, by Provinces, and Newfoundland	1337
— Central American Countries	1347
— Commercial Map Publishers	1330
— Dictionaries, Glossaries, Encyclopedias, Statistics, and Handbooks	1327
— Foreword. By J. V. Howell and A. I. Levorsen	1322
— General Material:—National and Continental in Area	1323
— Libraries Furnishing Photostat and Microfilm Service	1334
— Mexico	1348
— Miscellaneous Books and Publications of General Geological Interest	1328
— Publications and Non-Commercial Publishing Agencies, Regional, National, and Continental	1323
— Regional and National Geologic and Physiographic Maps	1331
— Specific Material:—State and Province in Area	1337
— State and Province Geological Maps	1332
— Thin-Section and Rock-Polishing Service	1336
— Trade Journals: Oil, Gas, Mineral Industry	1334
— United States—States and Territories	1349
Discussion	275, 620, 1053, 1589, 2035
Distinguished Lecture by T. S. Oakwood. At Home and Abroad	476
Distinguished Lecture Tour by Parke A. Dickey. At Home and Abroad	301
— by Paul H. Price. At Home and Abroad	1976
— by H. N. Fisk	2041

— by Wallace E. Pratt. At Home and Abroad	1977
— by William O. Hotchkiss. At Home and Abroad	1977
— by Horace G. Richards. At Home and Abroad	1069
— by Harold W. Scott. At Home and Abroad	301
— by W. H. Twenhofel. At Home and Abroad	807
Distribution of Oceans and Continents. By W. G. Woolnough	1981
Dixon, W. J., and Swesnik, R. M. Statistics of Exploratory Drilling. Discussion	2035
Dobbin, C. E. Abstract	749
—, chairman. Report of Committee for Publication. The Association Round Table	792
Dolomitization, Porosity through. By Kenneth K. Landes	305
Dorf, Erling, Graton, L. C., and Williams, Howel. Paracutin Volcano, Mexico. Review by John L. Ferguson	121
Dreher, Otto. Memorial by E. A. Ritter	1786
Drill Cuttings, West Virginia Geological Survey Collection of. Geological Note by James H. C. Martens	350
Durham, J. Wyatt. Abstract	2089
Eardley A. J. Petroleum Geology of Aquitaine Basin, France	1517
Eargle, D. Hoyer, Monroe, Watson H., and Conant, Louis C. Pre-Selma Upper Cretaceous Stratigraphy of Western Alabama	187
Earth, the Pulse of. By J. H. F. Umbgrove. Review by W. A. Ver Wiebe	279
Earth History, Geotectonic Subdivisions of. By Hans Stille. Review by W. A. Ver Wiebe	1200
East Indian Archipelago, Oil Basins of. By H. M. Schuppli	1
East Indies, Evolution of Reef Corals in, since Miocene Time. by J. H. F. Umbgrove	23
East Texas, Developments in 1945. By T. H. Shelby, Jr., and G. J. Loetterle	980
East Texas Geological Society Field Trip, December 1 and 2, 1945. Discussion by C. L. Moody	276
Eastern Interior Basin, Developments in 1945. By Alfred H. Bell	879
Eaton, J. E. Use of Quotation Mark in Science. Geological Note	1928
Eby, J. Brian, chairman. Report of Committee on Applications of Geology. The Association Round Table	784
Eckis, Rollin. Memorial of Robert W. Burger	803
Ector County, Texas, Devonian (?) Producing Zone, TXL Pool. Geological Note by Max David	118
Ecuador, Western, Micropaleontology of Upper Cretaceous and Paleocene in. By Hans E. Thalmann	337
Effects of World War II on California Oil Reserves. By Graham B. Moody. Abstract	2088
Egypt, Conodonts from Triassic of Sinai. Geological Note by D. B. Eicher	613
Eicher, D. B. Conodonts from Triassic of Sinai (Egypt). Geological Note	613
Election of Officers, Final Report of Committee on Method of. By John G. Bartram. The Association Round Table	134
Elias, Maxim K., Price, W. Armstrong, and Frye, John C. Algae Reefs in Cap Rock of Ogalalla Formation on Llano Estacado Plateau, New Mexico and Texas	1742
Ellis, Amsden, and Big Snowy Group, Judith Basin, Montana, By Paul T. Walton	1294
Ellis, Brooks F. Review of Principles of Micropaleontology, by M. F. Glaessner	1201
Ellison, Samuel P., Jr. Conodonts as Paleozoic Guide Fossils	93
Ellsworth, Elmer W., Appointed Assistant Business Manager. The Association Round Table	1211
Elmore Embayment, Garvin County, Oklahoma. Geological Note by Robert R. Wheeler	2034
Ely, Fred Burchard. Memorial by Gail F. Moulton	1616
Emmons, William Harvey—Honorary Member. By A. I. Levorsen. The Association Round Table	733
Engineering, Petroleum Production—Oil Field Development, by Lester Charles Uren. Review by Harry H. Power	2064
Eocene, Late Upper Cretaceous, and Paleocene Sandstones of Los Banos District, West Border of San Joaquin Valley, California, Mineralogy of. By S. N. Daviss	63
Estorff, Fritz E. von. Tectonic Framework of Northwestern South America	581
—, Discussion by Victor Oppenheim	1589
Evidence Supporting Lateral Migration of Oil, San Joaquin Valley, California. By Glenn C. Ferguson. Abstract	2090
Evolution of Reef Corals in East Indies since Miocene Time. By J. H. F. Umbgrove	23
Expanding Activities of Paleontologists. By John R. Sandidge	1088
Executive Committee. Memorial of Alexander Watts McCoy	292
Exploration for Oil in British Guiana, Report on. By H. G. Gugler <i>et al.</i> Review by H. D. Hedberg	120

Exploration and Development, 1945, Review of	813
Exploratory Drilling in 1945, Statistics of. By Frederic H. Lahee	813
Exploratory Drilling, Statistics of. Discussion by W. J. Dixon and R. M. Swesnik	2035
Exploratory Operations, Present, Geological Occurrence of Oil in United Kingdom with Reference to. By H. R. Lovely	1444, 1959
Facing Forward. By Eugene Holman	1099
Fairbridge, Rhodes W. Submarine Slumping and Location of Oil Bodies	84
Fall Meeting, Biloxi, Mississippi, October, 24-26, 1946. Announcement. The Association Round Table	1314, 1615
Fatty Acids, Formation of Hydrocarbons from, by Alpha-Particle Bombardment. By C. W. Sheppard and W. L. Whitehead	32
Fault Structures, Normal, and Others. By Bailey Willis	1875
Faulting, Apparent, Relations between Kinds of Well Data and. Geological Note by H. H. Suter	1910
— in East Part of Grand Canyon of Arizona. By C. E. Van Gundy	1899
Ferguson, Glenn C. Abstract	2090
Ferguson, John L. Review of Paracutin Volcano, Mexico, by L. C. Graton, Howel Williams, and Erling Dorf	121
Field Trip, East Texas Geological Society, December 1 and 2, 1945. Discussion by C. L. Moody	276
Final Reports on a Reconnaissance Survey of Research Needs in Petroleum Geology by the American Association of Petroleum Geologists Research Committee, 1945-1946. Foreword. By Shepard W. Lowman	2042
Financial Statement, Division of Paleontology and Mineralogy, for 1945. The Association Round Table	459
— for 1945. The Association Round Table	455
First Oligocene Mammalian Fauna from Northern South America. By R. A. Stirton. Abstract. The Association Round Table	131
Fisk, H. N., Distinguished Lecture Tour	2041
Foreword. Directory of Geological Material in North America. By J. V. Howell and A. I. Levorsen	1322
Formation of Evaporites under Marine Evaporation Conditions. By Paul Weaver. Abstract	1965
Formation of Hydrocarbons from Fatty Acids by Alpha-Particle Bombardment. By C. W. Sheppard and W. L. Whitehead	32
Fort Blend, Waller, and Harris Counties, Texas, Geology of Katy Field. By A. P. Allison, R. L. Beckelhymer, Don G. Benson, R. M. Hutchins, Jr., C. L. Lake, Ray C. Lewis, P. H. O'Bannon, S. R. Self, and C. A. Warner	157
Fossil Plants and Jurassic-Cretaceous Boundary in Montana and Alberta. By Roland W. Brown	238
Fossils, Paleozoic Guide, Conodonts as. By Samuel P. Ellison, Jr.	93
Framework, Tectonic, of Northwestern South America. By Fritz E. von Estorff	581
— Discussion by Victor Oppenheim	1589
— Discussion by Fritz E. von Estorff	2040
France, Petroleum Geology of Aquitaine Basin. By A. J. Eardley	1517
Frye, John C., Price, W. Armstrong, and Elias, Maxim K. Algae Reefs in Cap Rock of Ogallala Formation on Llano Estacado Plateau, New Mexico and Texas	1742
Fuellhart, Donald Egbert. Memorial by Dugald Gordon	468
Fugitt, Le Roy, and Montgomery, Porter A., Jr. Developments in Texas Panhandle in 1945	925
Functions and Organization of Geologic Names and Correlations Committee. By Henry J. Morgan, Jr. The Association Round Table	2079
Future of the Research Library and the Scholar, a Problem and Its Solution. By Fremont Rider. Review by Marcus A. Hanna	1592
Garvin County, Oklahoma, Elmore Embayment. Geological Note by Robert R. Wheeler	2034
Gas and Oil Field Development in United States, 1944. By National Oil Scouts and Landmen's Association. Review by W. A. Ver Wiebe	353
General Bibliographies on Geological Material	1326
General Geological Material—National and Continental in Area	1323
General Geology and Occurrence of Oil in Florida. By E. D. Pressler. Abstract	1965
Geographic Distribution of Members. The Association Round Table	769
Geologia de Bolivia, by F. Ahlfeld. Review by Norman D. Newell	2065
Geologic Contribution of a State to the Oil Industry. By Robert L. Bates. Abstract	751
Geologic Names and Correlations Committee, Functions and Organization of. By Henry J. Morgan, Jr. The Association Round Table	2079
Geologic Tool, Grain Roundness Valuable as. By Gordon Rittenhouse	1192

Geological Attack, The. By M. G. Cheney	1077
Geological Case Histories, Publication of. By Henry C. Cortes	1095
Geological-Geophysical Exploration, Recent Trends in. By R. Clare Coffin	2013
Geological Material, General—National and Continental in Area	1323
—, Specific—State and Province in Area	1337
Geological Notes 111, 348, 606, 711, 1051, 1198, 1306, 1585, 1764, 1910, 2034	2034
Geological Occurrence of Oil in United Kingdom with Reference to Present Exploratory Operations. By H. R. Lovely	1444
Geological Reconnaissance in Southeastern Peru. By Victor Oppenheim	254
— in Southeastern Perú. Discussion by H. E. Parsons	1053
Geological Results of Search for Oilfields in Great Britain. By G. M. Lees and A. H. Taitt. Review by D. A. Greig	1591
Geologist in World War II—A Memorial. By A. Rodger Denison	802
Geologists in Service (European Theater). By Paul H. Price. Abstract	740
Geologists' Place in Service. By Paul H. Price	1115
Geology as a Profession. At Home and Abroad	1219
— of Aliso Canyon, Field, Los Angeles County, California. By Claude E. Leach. Abstract	746
— of Basement Complex, Edison Oil Field, Kern County, California. By J. H. Beach and Harry Campbell. Abstract	2090
— of Katy Field, Waller, Harris, and Fort Bend Counties, Texas. By A. P. Allison, R. L. Beckelhymer, Don G. Benson, R. M. Hutchins, Jr., C. L. Lake, Ray C. Lewis, P. H. O'Bannon, S. R. Self, and C. A. Warner	157
— of Maracaibo Basin, Venezuela. By F. A. Sutton	1621
— By F. A. Sutton. Abstract	744, 1621
— of the Gilbertown Field, Choctaw County, Alabama. By A. M. Current. Abstract	1967
— of Tierra del Fuego, South America. By Joseph Hollister. Abstract. The Association Round Table	130
— of West Tepetate Oil Field, Jefferson Davis Parish, Louisiana. By Fred W. Bates and Jay B. Wharton. Abstract	1966
—, Petroleum, of Aquitaine Basin, France, By A. J. Eardley	1517
Geology and Science Legislation. By Carey Croneis	1104
Geotectonic Subdivisions of Earth History. By Hans Stille. Review by W. A. Ver Wiebe	1200
German Oil Fields, Status of. By Frank Reeves	1546
Glaessner, M. F. Principles of Micropaleontology. Review by Brooks F. Ellis	1201
Glendora Volcanics. By John S. Shelton. Abstract	2088
Golden, John Munro. Memorial by John H. Wilson	1970
Golden-Morrison Area, Jefferson County, Colorado, Stratigraphy of. By L. W. LeRoy	1055
Gordon, Dugald. Memorial of Donald Egbert Fuellhart	408
Grain Roundness—A Valuable Geologic Tool. By Gordon Rittenhouse	1192
Grain Size in Carbonate Rock. Geological Note by Ronald K. DeFord	1921
Gramp's Field, Archuleta County, Colorado. By W. A. Waldschmidt	561
Grand Canyon of Arizona, Faulting in East Part of. By C. E. Van Gundy	1899
Grand Canyon Region, Cambrian History of. By Edwin D. McKee and Charles E. Resser. Review	282
Graton, L. C., Williams, Howel, and Dorf, Erling. Paracutin Volcano, Mexico. Review by John L. Ferguson	121
Gravity in the East Indies and Its Interpretation. By F. A. Vening Meinesz. Abstract	743
Great Britain, Geological Results of Search for Oilfields in. By G. M. Lees and A. H. Taitt. Review by D. A. Greig	1591
Greig, D. A. Review of Geological Results of Search for Oilfields in Great Britain, by G. M. Lees and A. H. Taitt	1591
Guide Fossils, Paleozoic, Conodonts as. By Samuel P. Ellison, Jr.	93
Gulf Coast of Louisiana, Developments in 1945. By Fred W. Bates and Jay B. Wharton, Jr.	999
—, Upper, of Texas, Developments in 1945. By Donald M. Davis and Carl F. Beilharz	991
Half-Page Method of Manuscript Preparation. Geological Note by W. Armstrong Price	1198
Hanna, Marcus A. Review of The Scholar and the Future of the Research Library, a Problem and Its Solution, by Fremont Rider	1592
Hanna, M. A., and Lowman, S. W. Research Committee Calendar and Schedule. Research Note	1950
Harbolite: A Carbonaceous Hydrocarbon. Geological Note by Cevat E. Tasman	1051
Hardenberg, H. J. Developments in Michigan in 1945.	886
Harris, R. M., and Alexander, C. W. Abstract	1964
Harris and Waller Counties, Texas, Stratigraphy of. By R. L. Beckelhymer	52

Harris, Waller, and Fort Bend Counties, Texas, Geology of Katy Field. By A. P. Allison, R. L. Beckelhymer, Don G. Benson, R. M. Hutchins, Jr., C. L. Lake, Ray C. Lewis, P. H. O'Bannon, S. R. Self, and C. A. Warner	157
Hawkins Field, Wood County, Texas. By E. A. Wendlandt, T. H. Shelby, Jr., and John S. Bell	1830
———. By E. A. Wendlandt, T. H. Shelby, and John Bell. Abstract	746
Hazzard, Roy T. Abstract	1966
Hedberg, H. D. Review of Report of Exploration for Oil in British Guiana, by H. G. Kugler <i>et al.</i>	120
Heidelberg Field, Jasper County, Mississippi. By Tom McGlothlin. Abstract	1967
Heidelberg Field, Mississippi, Rowell Well No. 1. Discussion by Lloyd W. Stephenson	275
Henbest, Lloyd G. Abstract	750
Hendricks, Thomas A. Natural Resources Section in Japan and Korea. Geological Note	119
Hershey, Lewis B. Selective Service Memoranda 115 and 115-M. The Association Round Table	142
Hewett, D. F. Abstract	2091
Heyl, Allen V., Jr., and Agnew, Allen F. Quimbys Mill, New Member of Platteville Formation, Mississippi Valley. Geological Note	1585
Higgs, M. T., and Weaver, Paul. Abstract	749
Highlight of Washington and Oregon Biostratigraphy. By R. Stanley Beck. Abstract	2088
Hill, W. P. T. Abstract	740
Historical Notes on the Geology of Mississippi. By Urban B. Hughes. Abstract	1963
History of Reserves and Production of Natural Gas and Natural Gas Liquids in Texas. By Perry Olcott	1123
———. By D. Perry Olcott. Abstract	742
Hobson, H. D., and Coenen, E. J. Abstract	2090
Hoffmeister William S., and Robinson, Van Daniel. Developments in South Arkansas and North Louisiana in 1945	1007
Hogan, Dana. Memorial by J. R. Pemberton	1066
Holden, Roy J. Memorial by Heath M. Robinson	464
Hollister, Joseph. Geology of Tierra del Fuego, South America. Abstract. The Association Round Table	130
Holman, Eugene. Facing Forward	1099
Honorary Member—William Harvey Emmons. By A. I. Levorsen. The Association Round Table	733
———. Elias Howard Sellards. By M. G. Cheney. The Association Round Table	735
Hoots, Harold W., chairman. Report of Resolutions Committee. The Association Round Table	775
Hotchkiss, William O. Distinguished Lecture Tour. At Home and Abroad	1977
Houston Geological Society Student Awards. The Association Round Table	1069, 1210
Houston Geological Society Study Groups. At Home and Abroad	474
Howe, Henry V. Abstract	1965
Howell, J. V., and Levorsen, A. I. Directory of Geological Material in North America	1321
———. Foreword, Directory of Geological Material in North America	1322
Huddle, John W., Thomas, C. R., and Bass, N. W. Abstract	749
Hughes, Aden W. Abstract	2087
Hughes, Donald Dudley. Memorial by Eric K. Craig	1786
Hughes, Urban B. Abstract	1963
Hume, George S. Development in Canada in 1945	851
Hunt, Charles B. Abstract	741
Hutchins, R. M., Jr., Allison, A. P. Beckelhymer, R. L., Benson, Don G., Lewis, Ray C., O'Bannon, P. H., Self, S. R., and Warner, C. A. Geology of Katy Field, Waller, Harris, and Fort Bend Counties, Texas	157
Hydrocarbon, Carbonaceous: Harbolite. Geological Note by Cevat E. Tasman	1051
Hydrocarbons, Formation of, from Fatty Acids by Alpha-Particle Bombardment. By C. W. Sheppard and W. L. Whitehead	32
Interim Report of Research Committee. By S. W. Lowman. Research Note	265
Investigations, Recent, by United States Geological Survey of Petroleum Possibilities in Alaska. By John C. Keed	1433
"Jacob Staff" and Measurements of Stratigraphic Sequences. Geological Note by J. A. Broggi	716, 1934
Japan and Korea, Natural Resources Section in. Geological Note by Thomas A. Hendricks	119
Jenkins, H. D., and McGee, D. A. West Edmond Oil Field, Central Oklahoma	1797
Joint Annual Meeting, Stevens Hotel, Chicago, April 1-4, 1946. Announcement. The Associa-	

tion Round Table	156, 289, 460
Judith Basin, Montana, Ellis, Amsden, and Big Snowy Group. By Paul T. Walton	1294
Jurassic-Cretaceous Boundary and Fossil Plants in Montana and Alberta. By Roland W. Brown	238
Kansas, Central, Buried Pre-Cambrian Hills in Northeastern Barton County. By Robert F. Walters	660
—, Central, Siluro-Devonian Strata in. By Hall Taylor	1221
—, Kinderhook Dolomite of Sedgwick County. By W. A. Ver Wiebe	1747
Katy Field, Waller, Harris, and Fort Bend Counties, Texas, Geology of. By A. P. Allison, R. L. Becklhymer, Don G. Benson, R. M. Hutchins, Jr., C. L. Lake, Ray C. Lewis, P. H. O'Bannon, S. R. Self, and C. A. Warner	157
Kinderhook Dolomite of Sedgwick County, Kansas. By W. A. Ver Wiebe	1747
King, Philip B. Report of Sub-Committee on Tectonics	2042
King, Robert E. Stratigraphy of Oil Producing Zones of Pre-San Andres Formations of South-eastern New Mexico. Review by E. Russell Lloyd	278
Kinney, Douglas M. Age of Penters Chert, Batesville District, Arkansas. Geological Note	611
Knebel, G. M. Abstract	748
—, Progress Report on A.P.I. Research Project No. 43—Transformation of Organic Material into Petroleum. Research Note	1935
Koester, Edward A., chairman. Minutes of Special Meeting. The Association Round Table	798
—, Minutes, Thirty-First Annual Business Meeting, Stevens Hotel, Chicago, April 1-4, 1946. The Association Round Table	755
—, Report of Secretary-Treasurer. The Association Round Table	704
—, Review of The Wildcatters, by Samuel W. Tait, Jr.	1308
Koester, Edward A., and Cole, Virgil B. Developments in North Mid-Continent in 1945	895
Korea and Japan, Natural Resources Section in. Geological Note by Thomas A. Hendricks	119
Krampert, E. W. Developments in Rocky Mountain Region in 1945	912
Krueger, Max L., and Thomas, Horace D. Late Paleozoic and Early Mesozoic Strata of the Uinta Mountains, Utah. Abstract. The Association Round Table	131
Krueger, Max L., and Thomas, Horace D. Late Paleozoic and Early Mesozoic Stratigraphy of Uinta Mountains, Utah	1255
Kugler, H. G., <i>et al.</i> Report on Exploration for Oil in British Guiana. Review by H. D. Hedberg	120
Lahee, Frederic H. Abstract	749
—, chairman. Report of Committee on Statistics of Exploratory Drilling. The Association Round Table	791
—, Statistics of Exploratory Drilling in 1945	813
Laird, Wilson M., and Sloss, Laurence L. Abstract	751
Lake, C. L., Allison, A. P., Beckelhymer, R. L., Benson, Don G., O'Bannon, P. H., Lewis, Ray C., Hutchins, R. M., Jr., Self, S. R., and Warner, C. A., Geology of Katy Field, Waller, Harris, and Fort Bend Counties, Texas	157
Lammers, Edward C. H. Notes on Rocky Mountain Thrust Faults. Abstract. The Association Round Table	132
Landes, Kenneth K. Porosity through Dolomitization	305
Landslides—Ventura Avenue Oil Field. By Claude Leach and Henry H. Neel. Abstract. The Association Round Table	134
Lantern Slides, Preparation of. Geological Note by G. Zuloaga	1771
Las Animas Arch in Baca, Las Animas, and Otero Counties, Colorado, Correlation of Paleozoic Rocks across. By John C. Maher	1756
Late Paleozoic and Early Mesozoic Stratigraphy of Uinta Mountains, Utah. By Horace D. Thomas and Max L. Krueger	1255
Late Paleozoic and Early Mesozoic Strata of the Uinta Mountains, Utah. By Horace D. Thomas and Max L. Krueger. Abstract. The Association Round Table	131
Leach, Claude E. Abstract	746
Leach, Claude, and Neel, Henry H. Landslides—Ventura Avenue Oil Field. Abstract. The Association Round Table	134
Ledingham, Glenn W. Abstract	2090
Lees, G. M., and Taitt, A. H. Geological Results of Search for Oilfields in Great Britain. Review by D. A. Greig	1591
LeRoy, L. W. Stratigraphy of Golden-Morrison Area, Jefferson County, Colorado	1055
Levings, W. S., Van Tuyl, F. M., and Others. Review of Petroleum Geology in 1945. Review by Robert F. Walters	1955
Levorsen, A. I. Survey of College Students Majoring in Geology. Research Note	730
—, William Harvey Emmons—Honorary Member. The Association Round Table	733

Levorsen, A. I. Abstract	2089
Levorsen, A. I., and Howell, J. V. Directory of Geological Material in North America	1321
— Foreword, Directory of Geological Material in North America	1322
Limestones, Spectrochemical Sample Logging of. By L. L. Sloss and S. R. B. Cooke	1888
Link, Theodore A. Abstract	747
Llano Estacado Plateau, New Mexico and Texas, Algae Reefs in Cap Rock of Ogallala Formation on. By W. Armstrong Price, Maxim K. Elias, and John C. Frye	1742
Lloyd, A. M., and Totten, R. B. Abstract	1967
Lloyd, E. Russell. Review of Stratigraphy of Oil Producing Zones of Pre-San Andres Formations of Southeastern New Mexico, by Robert E. King	278
Lockett, J. R. Abstract	743
Loetterle, G. J., and Shelby, T. H., Jr. Developments in East Texas during 1945	980
Longwell, Chester R. Abstract	742
Los Banos District, West Border of San Joaquin Valley, California, Mineralogy of Late Upper Cretaceous, Paleocene, and Eocene Sandstones of. By S. N. Daviss	63
Louisiana, Gulf Coast of, Developments in 1945. By Fred W. Bates and Jay B. Wharton, Jr.	999
— North, and South Arkansas, Developments in 1945. By William S. Hoffmeister and Van Daniel Robinson	1007
Lovely, H. R. Geological Occurrence of Oil in United Kingdom with Reference to Present Exploratory Operations	1444, 1959
Lower Middle Ordovician of Southwest Virginia and Northeast Tennessee. By Chilton E. Prouty	1140
Lower Pennsylvanian Terminology in Central Texas. By R. C. Spivey and T. G. Roberts	181
Lowman, S. W., and Hanna, M. A. Research Committee Calendar and Schedule. Research Note	1950
Lowman, Shepard W., chairman. Report of Research Committee. The Association Round Table	787
— Final Reports on a Reconnaissance Survey of Research Needs in Petroleum Geology by the American Association of Petroleum Geologists Research Committee, 1945-1946. Foreword	2042
— Interim Report of Research Committee. Research Note	265
MacNeil, F. Stearns. Abstract	1965
Maher, John C. Abstract	752
— Correlation of Paleozoic Rocks across Las Animas Arch in Baca, Las Animas, and Otero Counties, Colorado	1756
Manuscript Preparation, Half-Page Method of. Geological Note by W. Armstrong Price	1198
Maracaibo Basin, Venezuela, Geology of. By F. A. Sutton	1621
Marine Microbiology. By Claude E. ZoBell. Review by Robert W. Stone	1308
Marine Sedimentary Cycles of Tertiary in Mississippi Embayment. By Max Bornhauser. Abstract	745
Marine Sediments, Studies on Redox Potential of. By Claude E. ZoBell	477
Martens, James H. C. West Virginia Geological Survey Collection of Drill Cuttings. Geological Note	350
McCoy, Alexander Watts. Memorial by the Executive Committee	292
McGee, D. A. Abstract	746
McGee, D. A., and Jenkins, H. D. West Edmond Oil Field, Central Oklahoma	1797
McGlothlin, Tom. Abstract	1967
McKee, Edwin D., and Resser, Charles E. Cambrian History of Grand Canyon Region. Review	282
McLellan, H. J. Raccoon Bend Salt Dome, Austin County, Texas. Geological Note	1306
Meinesz, F. A. Vening. Abstract	746
Mellen, F. F. Abstract	1963
Membership Applications	155, 302, 629, 799, 1059, 1208, 1588, 1979, 2079
Members of A.A.P.G. in Armed Forces of United States and Allied Nations. The Association Round Table	782
— in Civilian Capacities with Government in War Effort. The Association Round Table	783
Membership List of the Association, March 2, 1946. The Association Round Table	361
— Supplementary, September 1, 1946. The Association Round Table	1610
Memorial	292, 463, 633, 802, 1065, 1213, 1315, 1616, 1786, 1969
— The Geologist in World War II. By A. Rodger Denison	802
Mesozoic, Early, and Late Paleozoic Stratigraphy of Uinta Mountains, Utah. By Horace D. Thomas and Max L. Krueger	1255
Mesozoic Igneous Rocks of the Northern Gulf Coastal Plain. By C. L. Moody. Abstract	1966

Method of Election of Officers, Final Report of Committee on. By John G. Bartram. The Association Round Table	134
— of Manuscript Preparation, Half-Page. Geological Note by W. Armstrong Price	1198
Mexico, Percutin Volcano. By L. C. Graton, Howel Williams, and Erling Dorf. Review by John L. Ferguson	121
—, Stratigraphy Near Caborca, Northwest Sonora. Geological Note by G. Arthur Cooper and Alberto R. V. Arellano	606
Meyerhoff, Howard A. Abstract	744
Michigan, Developments in 1945. By H. J. Hardenberg	886
Micropaleontology of Upper Cretaceous and Paleocene in Western Ecuador. By Hans E. Thalmann	337
—, Principles of: By M. F. Glaessner. Review by Brooks F. Ellis	1201
Mid-Continent, North, Developments in 1945. By Virgil B. Cole and Edward A. Koester	895
Mid-Continent Regional Meeting, Wichita, Kansas, January 16-17, 1947. The Association Round Table	1784, 1968, 2078
— Announcement. The Association Round Table	1615
Mid-Year Meeting, Biloxi, Mississippi, October 24, 25, 26. Announcement. The Association Round Table	1212
Mineralogy of Late Upper Cretaceous, Paleocene, and Eocene Sandstones of Los Banos District, West Border of San Joaquin Valley, California. By S. N. Daviess	63
Minutes of Business Committee, Stevens Hotel, Chicago, 1946. By Robert W. Clark, chairman. The Association Round Table	794
— of Special Meeting, Stevens Hotel, Chicago, 1946. By Edward A. Koester, chairman. The Association Round Table	798
—, Thirty-First Annual Business Meeting, Stevens Hotel, Chicago, April 2 and 4, 1946. By Edward A. Koester. The Association Round Table	755
Miocene Conglomerates of Puente and San Jose Hills, California. By A. O. Woodford, T. G. Moran, and J. S. Shelton	514
Miocene Time, Evolution of Reef Corals in East Indies since. By J. H. F. Umbgrove	23
Mississippi, Rowell Well No. 1, Heidelberg Field. Discussion by Lloyd W. Stephenson	275
Mississippi Valley, Quimbys Mill, New Member of Platteville Formation. Geological Note by Allen F. Agnew and Allen V. Heyl, Jr.	1585
Mississippian Subsurface Formation, New, in Southeast Nebraska, Boice Shale. Geological Note by E. C. Reed	348
Montana, Ellis, Amsden, and Big Snowy Group, Judith Basin. By Paul T. Walton	1294
Montana and Alberta, Fossil Plants and Jurassic-Cretaceous Boundary in. By Roland W. Brown	238
Montgomery, Porter A., Jr., and Fugitt, Le Roy. Developments in Texas Panhandle in 1945	925
Monroe, Watson H. Abstract	1963
Monroe, Watson H., Conant, Louis C., and Eargle, D. Hoyer. Pre-Selma Upper Cretaceous Stratigraphy of Western Alabama	187
Moody, C. L., chairman. Report of Trustees of Research Fund. The Association Round Table	777
— Abstract	1966
— East Texas Geological Society Field Trip, December 1 and 2, 1945. Discussion	276
— Memorial of Albert Foster Crider	633
Moody, Graham B. Abstract	2088
— Developments in California in 1945	829
Moore, Fred H., chairman. Report of Distinguished Lecture Committee. The Association Round Table	776
Moran, T. G., Woodford, A. O., and Shelton, J. S. Miocene Conglomerates of Puente and San Jose Hills, California	514
Morgan, Henry J., Jr. Functions and Organization of Geologic Names and Correlations Committee. The Association Round Table	2079
Morrison-Golden Area, Jefferson County, Colorado, Stratigraphy of. By L. W. LeRoy	1055
Moulton, Gail F. Memorial of Fred Burchard Ely	1616
Muller, Siemon Wm. Abstract	2089
Multiple Sands, Suggestions for Naming. Geological Note by Roy E. Dickerson and H. W. Straley, III	115
Murray, Grover E., Jr. Abstract	1964
Naming Multiple Sands, Suggestions for. Geological Note by Roy E. Dickerson and H. W. Straley, III	115
National Oil Scouts and Landmen's Association. Oil and Gas Field Development in United States, 1944. Review by W. A. Ver Wiebe	353

National Research Council, Report of Representative on Division of Geology and Geography of, 1945-1946. By M. G. Cheney, representative. The Association Round Table	792
Natural Gas and Natural Gas Liquids, Production of, and Reserves in Texas, History of. By Perry Olcott	1123
Natural Gas Liquids and Natural Gas, Production of, and Reserves in Texas, History of. By Perry Olcott	1123
Natural Resources Section in Japan and Korea. Geological Note by Thomas A. Hendricks	119
Nebraska, Southeast, Boice Shale, New Mississippian Subsurface Formation in. Geological Note by E. C. Reed	348
Neel, Henry H., and Leach, Claude. Landslides—Ventura Avenue Oil Field. Abstract. The Association Round Table	134
Nehalem River Basin, Upper, Northwestern Oregon, Stratigraphy of. By W. C. Warren and Hans Norbistrath	213
Nelson, Loyal E. Abstract	2091
New General Staff Group to Coordinate Military, Civilian Research Projects. At Home and Abroad	1072
New Geologic Map of Tertiary Formations of Georgia. By F. Stearns MacNeil. Abstract	1965
New Member of Platteville Formation (Quimbys Mill), Mississippi Valley. Geological Note by Allen F. Agnew and Allen V. Heyl, Jr.	1585
New Mexico, Northern, Western New Mexico, and Arizona. Developments in 1945. By Robert L. Bates	958
—, Southeast, and West Texas. Correlation of Permian of. By John W. Skinner	1857
—, Southeastern, Stratigraphy and Oil Producing Zones of Pre-San Andres Formation of. By Robert E. King. Review by Russell E. Lloyd	278
—, Southeastern, and West Texas. Developments in 1945. By E. Hazen Woods, C. L. Chase, and J. E. Bucher	930
—, Western, Northern New Mexico, and Arizona. Developments in 1945. By Robert L. Bates	958
New Mexico and Texas, Algae Reefs in Cap Rock of Ogallala Formation of Llano Estacado Plateau. By W. Armstrong Price, Maxim K. Elias, and John C. Frye	1742
New Rock-Color Chart for Field Use. The Association Round Table	2091
Newell, Norman D. Review of <i>Geologia de Bolivia</i> , by F. Ahlfeld	2065
Nominating Committee, Report of. By Frank R. Clark, chairman. The Association Round Table	1609
Nominees for Officers, 1947-1948	2082
Norbistrath, Hans, and Warren, W. C. Stratigraphy of Upper Nehalem River Basin, Northwestern Oregon	213
Normal Fault Structures and Others. By Bailey Willis	1875
North Carolina, Continental Slope of, and Atlantic Coastal Plain Floor. Geological Note by W. F. Prouty	1917
North Louisiana and South Arkansas, Developments in 1945. By William S. Hoffmeister and Van Daniel Robinson	1007
North and West-Central Texas, Developments in 1945. By North Texas Geological Society.	963
North Texas Geological Society. Developments in North and West-Central Texas in 1945.	963
Northwestern South America, Tectonic Framework of. By Fritz E. von Estorff	581
—, Discussion by Victor Oppenheim	1589
—, Discussion by Fritz E. von Estorff	2040
Northwest Sonora, Mexico, Stratigraphy Near Caborca. Geological Note by G. Arthur Cooper and Alberto R. V. Arellano	606
Northwestern Oregon, Stratigraphy of Upper Nehalem River Basin. By W. C. Warren and Hans Norbistrath	213
Notes on Geology of Deep Coles Levee Well, Kern County, California. By N. L. Taliaferro and W. F. Barbat. Abstract. The Association Round Table	132
— on Rocky Mountain Thrust Faults. By Edward C. H. Lammers. Abstract. The Association Round Table	132
— on the Stratigraphy of the Santa Maria District. By Aden W. Hughes. Abstract	2087
Nugent, L. E., Jr. Some Developments in Aerial Photography during the War. Geological Note	725
Oakwood, T. S. Distinguished Lecture. At Home and Abroad	476
O'Bannon, P. H., Allison, A. P., Beckelhymer, R. L., Lake, C. L., Lewis, Ray C., Hutchins, R. M., Jr., Benson, Don G., Self, S. R., and Warner, C. A. Geology of Katy Field, Waller, Harris, and Fort Bend Counties, Texas	157
Oceanography and Petroleum Geology. By Fred B. Phleger, Jr. Abstract	741

Oceans and Continents, Distribution of. By W. G. Woolnough	1981
Occurrence of Oil, Geological, in United Kingdom with Reference to Present Exploratory Operations. By H. R. Lovely	1444, 1950
Officers, Nominees for, 1947-1948	2082
Ogallala Formation on Llano Estacado Plateau, New Mexico and Texas, Algae Reefs in Cap Rock of. By W. Armstrong Price, Maxim K. Elias, and John C. Frye	1742
Oil in British Guiana, Report on Exploration for. By H. G. Kugler <i>et al.</i> Review by H. D. Hedberg	120
Oil in United Kingdom, Geological Occurrence of, with Reference to Present Exploratory Operations. By H. R. Lovely	1444, 1959
Oil and Gas Field Development in United States, 1944. By National Oil Scouts and Landmen's Association. Review by W. A. Ver Wiebe	353
Oil Basins of East Indian Archipelago. By H. M. Schuppli	1
Oil Bodies, Submarine Slumping and Location of. By Rhodes W. Fairbridge	84
Oil Field Development—Petroleum Production Engineering, by Lester Charles Uren. Review by Harry H. Power	2064
Oil Fields, Asphaltic Sands Found to Occur in. Geological Note by D. B. Taliaferro and K. E. Stanfield	616
— in Great Britain, Geological Results of Search for. By G. M. Lees and A. H. Taitt. Review by D. A. Greig	1591
— of Carpathian Region. By Ray P. Walters	319
—, Status of German. By Frank Reeves	1546
Oil Possibilities, Outline for Classification of. Geological Note by Frank Reeves	111
Oil Producing Zones and Stratigraphy of Pre-San Andres Formations of Southeastern New Mexico. By Robert E. King. Review by E. Russell Lloyd	278
Oklahoma, Central, West Edmond Oil Field. By D. A. McGee and H. D. Jenkins	1797
—, Elmore Embayment, Garvin County. Geological Note by Robert R. Wheeler	2034
—, Developments in 1945. By Joseph L. Borden	902
Olcott, D. Perry. Abstract	742
Olcott, Perry. History of Reserves and Production of Natural Gas and Natural Gas Liquids in Texas	1123
Oölite and Oölith. Geological Note by Ronald K. DeFord and W. A. Waldschmidt	1587
Oppenheim, Victor. Geological Reconnaissance in Southeastern Peru	254
—, Tectonic Framework of Northwestern South America, by Fritz E. von Estorff. Discussion	1589
Organic Material, Transformation of, into Petroleum. Progress Report on A.P.I. Research Project No. 43. By G. M. Knebel	1935
—, Transformation of, into Petroleum under Geological Conditions (The Geological Fence) By Ben B. Cox	645
Organization, Functions and, of Geologic Names and Correlations Committee. By Henry J. Morgan, Jr. The Association Round Table	2079
Ordovician, Lower Middle, of Southwest Virginia and Northeast Tennessee. By Chilton E. Prouty	1140
Oregon, Northwestern, Stratigraphy of Upper Nehalem River Basin. By W. C. Warren and Hans Norbistrath	213
Origin and Migration of Oil into Sespe Red Beds. By Thomas L. Bailey. Abstract	2089
Origin of Continental Shelves. By J. H. F. Umbgrove	249
Ostracoda in Paleogeography. By W. T. Rothwell, Jr. Abstract	2087
Outline for Classifications of Oil Possibilities. Geological Note by Frank Reeves	111
Pacific, Tectonic Development of the Americas to Form the East Rim of. By Hans Stille. Review by W. A. Ver Wiebe	1054
Pacific Section Abstracts. The Association Round Table	128, 2087
Pacific Section Annual Meeting, Los Angeles, California, November 7-8, 1946	2087
Pacific Section Twenty-Second Annual Meeting, November 8 and 9, 1945. Abstracts. The Association Round Table	128, 2078
Paleocene and Upper Cretaceous in Western Ecuador, Micropaleontology of. By Hans E. Thalmann	337
Paleocene, Late Upper Cretaceous, and Eocene Sandstones of Los Banos District, West Border of San Joaquin Valley, California, Mineralogy of. By S. N. Daviess	63
Paleontologists, Expanding Activities of. By John R. Sandidge	1088
Paleozoic, Late, and Early Mesozoic Stratigraphy of Uinta Mountains, Utah. By Horace D. Thomas and Max L. Krueger	1255
Paleozoic Guide Fossils, Conodonts as. By Samuel P. Ellison, Jr.	93

Paleozoic Rocks, Correlation of, across Las Animas Arch in Baca, Las Animas, and Otero Counties, Colorado. By John C. Maher	1756
Pan-American Congress of Mining Engineering and Geology. At Home and Abroad	1620
Papers on S.E.G. Program. Joint Annual Meeting, 1946	754
— on S.E.P.M. Program, Joint Annual Meeting, 1946	752
Paracutin Volcano, Mexico. By L. C. Graton, Howel Williams, and Erling Dorf. Review by John L. Ferguson	121
Parker, Frank S. Results of California Exploration during the War Period. Abstract. The Association Round Table	128
Parsons, H. E. Geological Reconnaissance in Southeastern Perú. Discussion	1053
Past and Present Officers of the Association. The Association Round Table	360
Pemberton, J. R. Memorial of Dana Hogan	66
Pennsylvanian, Lower, Terminology in Central Texas. By R. C. Spivey and T. G. Roberts	181
Penters Chert, Batesville District, Arkansas, Age of. Geological Note by Douglas M. Kinney	611
Permafrost and Related Engineering Problems. By Siemon Wm. Muller. Abstract	2089
Permian of West Texas and Southeast New Mexico, Correlation of. By John W. Skinner	1857
—, Titles of Papers on, Joint Annual Meeting, 1946	753
Peru, Southeastern, Geological Reconnaissance in. By Victor Oppenheim	254
—, Discussion by H. E. Parsons	1053
Petroleum, Transformation of Organic Material into, under Geological Conditions (The Geological Fence). By Ben B. Cox	645
Petroleum Engineering, Trends and Developments in. By Stuart E. Buckley	1131
Petroleum Geology of Aquitaine Basin, France. By A. J. Eardley	1517
Petroleum Geology in 1945, Review of. By F. M. Van Tuyl, W. S. Levings, and Others. Review by Robert F. Walters	1955
Petroleum on the Continental Shelves. By Wallace Pratt. Abstract	2090
Petroleum Possibilities in Alaska, Recent Investigations of, by United States Geological Survey. By John C. Reed	1433
Petroleum Production Engineering—Oil Field Development, by Lester Charles Uren. Review by Harry H. Power	2064
Phleger, Fred B., Jr. Abstract.	741
Photography, Aerial, Some Developments in, during the War. Geological Note by L. E. Nugent, Jr.	725
— of Megafossils. Discussion by Floyd K. Beach	620
Physical Measurements in Wells for Geologic Data. By M. T. Higgs and Paul Weaver. Abstract	749
Plants, Fossil, and Jurassic-Cretaceous Boundary in Montana and Alberta. By Roland W. Brown	238
Platteville Formation, Quimby's Mill, New Member of, Mississippi Valley. Geological Note by Allen F. Agnew and Allen V. Heyl, Jr.	1585
Porosity through Dolomitization. By Kenneth K. Landes	305
Post-Triassic Evolution of Part of Atlantic Coastal Region. By W. T. Thom, Jr.	742
Power, Harry H. Review of Petroleum Production Engineering—Oil Field Development, by Lester Charles Uren	2064
Pratt, Wallace. Abstract	2090
—, Distinguished Lecture Tour. At Home and Abroad	1977
Pre-Cambrian Hills, Buried, in Northeastern Barton County, Central Kansas. By Robert F. Walters	660
Preparation of Lantern Slides. Geological Note by G. Zuloaga	1771
Pre-San Andres Formations of Southeastern New Mexico, Stratigraphy and Oil Producing Zones of. By Robert E. King. Review by E. Russell Lloyd	278
Pre-Selma Upper Cretaceous Stratigraphy of Western Alabama. By Watson H. Monroe, Louis C. Conant, and D. Hoye Eargle	187
President's Award, Recipient of—Horace Gardiner Richards. By Frank R. Clark. The Association Round Table	736
Pressler, E. D. Abstract	1965
Price, Paul H. Abstract	740
—, Distinguished Lecture Tour. At Home and Abroad	1976
—, Geologists' Place in Service	1115
Price, W. Armstrong. Abstract	745
—, Half-Page Method of Manuscript Preparation. Geological Note	1198
Price, W. Armstrong, Elias, Maxim K., and Frye, John C. Algae Reefs in Cap Rock of Ogallala Formation on Llano Estacado Plateau, New Mexico and Texas	1742
Principles of Micropaleontology. By M. F. Glaessner. Review by Brooks F. Ellis	1201

Processes and Products of Weathering, A Survey. By Parry Reiche. Review by Ronald K. DeFord	280
Production Engineering, Petroleum—Oil Field Development, by Lester Charles Uren. Review by Harry H. Power	2064
Production of Natural Gas and Natural Gas Liquids, and Reserves in Texas, History of. By Perry Olcott	1123
Program of Technical Papers. The Association Round Table	740
Progress Report on A.P.I. Research Project No. 43—Transformation of Organic Material into Petroleum. Research Note by G. M. Knebel	1935
— Abstract	748
Prouty, Chilton E. Lower Middle Ordovician of Southwest Virginia and Northeast Tennessee	1140
Prouty, W. F. Atlantic Coastal Plain Floor and Continental Slope of North Carolina. Geological Note	1917
Publication of Geological Case Histories. By Henry C. Cortes	1095
Puente and San Jose Hills, California, Miocene Conglomerates of. By E. O. Woodford, T. G. Moran, and J. S. Shelton	514
Pulse of the Earth. By J. H. F. Umbgrove. Review by W. A. Ver Wiebe	279
Putnam, William C. Abstract	741
Quaternary Diastrophic Activity on Coastal Plain of Western Gulf of Mexico. By W. Armstrong Price. Abstract	745
Quimbys Mill, New Member of Platteville Formation, Upper Mississippi Valley. Geological Note by Allen F. Agnew and Allen V. Heyl, Jr.	1585
Quotation Mark, Use of, in Science. Geological Note by J. E. Eaton	1928
Raccoon Bend Salt Dome, Austin County, Texas. Geological Note by H. J. McLellan	1306
Ramona Field, Los Angeles and Ventura Counties, California. By Loyal E. Nelson. Abstract	2091
Rangely Oil Field, Rio Blanco County, Colorado. By C. R. Thomas, John W. Huddle, and N. W. Bass. Abstract	749
Recent Investigations by the Geological Survey of Alaska Petroleum Possibilities. By John C. Reed. Abstract. The Association Round Table	131
— by United States Geological Survey of Petroleum Possibilities in Alaska. By John C. Reed	1433
Recent Publications	122, 283, 354, 625, 731, 1055, 1202, 1309, 1593, 1772, 1956, 2067
Recent Trends in Geological-Geophysical Exploration. By R. Clare Coffin	2013
— in Geological-Geophysical Exploration, and Methods of Improving the Use of Geophysical Data. By R. Clare Coffin. Abstract	748
Reconnaissance, Geological, in Southeastern Perú. Discussion by H. E. Parsons	1053
—, Geological, in Southeastern Peru. By Victor Oppenheim	254
Redox Potential of Marine Sediments, Studies on. By Claude E. ZoBell	477
Reed, E. C. Boice Shale, New Mississippian Subsurface Formation in Southeast Nebraska. Geological Note	348
Reed, John C. Recent Investigations by the Geological Survey of Alaska Petroleum Possibilities. Abstract. The Association Round Table	131
— Recent Investigations by United States Geological Survey of Petroleum Possibilities in Alaska	1433
Reed, Lyman C. San Pedro Oil Field, Province of Salta, Northern Argentina	591
Reef Corals in East Indies, Evolution of, since Miocene Time. By J. H. F. Umbgrove	23
Reeves, Frank. Outline for Classification of Oil Possibilities. Geological Note	111
— Status of German Oil Fields	1546
Relations between Kinds of Well Data and Apparent Faulting. Geological Note by H. H. Suter	1910
Relationship of Crude Oils and Stratigraphy in Parts of Oklahoma and Kansas. By Tulsa Geological Society Research Committee. Abstract	747
Regional and Oil-Field Papers. Abstracts	749
Reiche, Parry. A Survey of Weathering Processes and Products. Review by Ronald K. DeFord	280
Report, Final, of Committee on Method of Election of Officers. By John G. Bartram. The Association Round Table	134
— of Business Committee. By Robert W. Clark, chairman. The Association Round Table	757
— of Committee for Publication. By C. E. Dobbin, chairman. The Association Round Table	792
— of Committee on Applications of Geology. By J. Brian Eby, chairman. The Association Round Table	

tion Round Table	784
— of Committee on Boy Scout Literature. By Max W. Ball, chairman. The Association Round Table	785
— of Committee on Geologic Names and Correlations. By John G. Bartram, chairman. The Association Round Table	790
— of Committee on Statistics of Exploratory Drilling. By F. H. Lahee, chairman. The Association Round Table	791
— of Distinguished Lecture Committee. By Fred H. Moore, chairman. The Association Round Table	776
— of Editor. By Gayle Scott. The Association Round Table	774
— of Medal Award Committee. By Frank R. Clark, chairman. The Association Round Table	785
— of National Service Committee. By F. L. Aurin, chairman. The Association Round Table	778
— of Nominating Committee. By Frank R. Clark, chairman. The Association Round Table	1609
— of President. By M. G. Cheney. The Association Round Table	761
— of Representatives on Commission on Classification and Nomenclature of Rock Units. By C. W. Tomlinson, chairman. The Association Round Table	777
— of Representative on Division of Geology and Geography of National Research Council, 1945-1946. By M. G. Cheney, representative. The Association Round Table	792
— of Research Fund Trustees. By C. L. Moody, chairman. The Association Round Table	777
— of Resolutions Committee. By Harold W. Hoots, chairman. The Association Round Table	775
— of Research Committee. By Shepard W. Lowman, chairman. The Association Round Table	787
— of Secretary-Treasurer. By Edward A. Koester. The Association Round Table	764
— of Sub-Committee on Tectonics. By Philip B. King	2042
— of Trustees of Research Fund. By C. L. Moody. The Association Round Table	777
— on Exploration for Oil in British Guiana. By H. G. Kugler <i>et al.</i> Review by H. D. Hedberg	120
Research Committee Calendar and Schedule. Research Note by S. W. Lowman and M. A. Hanna	1950
—, Interim Report of. By S. W. Lowman. Research Note	265
Research Library, the Scholar and the Future of, a Problem and Its Solution. By Fremont Rider. Review by Marcus A. Hanna	1592
Research Needs in Petroleum Geology, Final Reports on a Reconnaissance Survey of, by the American Association of Petroleum Geologists Research Committee, 1945-1946. Foreword. By Shepard W. Lowman.	2042
Research Notes	265, 730, 1935, 1950, 2042
Reserves and Production of Natural Gas and Natural Gas Liquids in Texas, History of. By Perry Olcott	1123
Resources Section, Natural, in Japan and Korea. Geological Note by Thomas A. Hendricks	119
Resser, Charles E., and McKee, Edwin D. Cambrian History of Grand Canyon Region. Review	282
Results of California Exploration during the War Period. By Frank S. Parker. Abstract. The Association Round Table	128
Résumé of Oil and Gas Developments in Canada and the United States in 1945. By C. E. Dobbin. Abstract	749
Retraining Program in Geology, Veterans. By W. H. Bradley	290
Review of Exploration and Development in 1945	813
— Petroleum Geology in 1945, by F. M. Van Tuyl, W. S. Levings, and Others. Review by Robert F. Walters	1955
Reviews and New Publications	120, 278, 353, 625, 731, 1054, 1200, 1308, 1591, 1772, 1955, 2064
Rich, John L. Abstract.	743
Richards, Horace Gardiner. Distinguished Lecture Tour. At Home and Abroad	1069
—, Recipient of President's Award. By Frank R. Clark. The Association Round Table	736
Rider, Fremont. The Scholar and the Future of the Research Library, a Problem and Its Solution. Review by Marcus A. Hanna	1592
Rittenhouse, Gordon. Grain Roundness—A Valuable Geologic Tool	1192
Ritter, E. A. Memorial of Otto Dreher	1786
Roberts, T. G., and Spivey, R. C. Lower Pennsylvanian Terminology in Central Texas	181
Robinson, Ernest G. Memorial of Karl Howard Schilling	1969

Robinson, Heath M. Memorial of Roy J. Holden	464
Robinson, Van Daniel, and Hoffmeister, William S. Developments in South Arkansas and North Louisiana in 1945	1007
Rock-Color Chart, New for Field Use. The Association Round Table	2091
Rocky Mountain Region, Developments in 1945. By E. W. Krampert	912
Rothwell, W. T., Jr. Abstract	2087
Rowell Well No. 1, Heidelberg Field, Mississippi. Discussion by Lloyd W. Stephenson	275
Salta, Province of, Northern Argentina, San Pedro Oil Field. By Lyman C. Reed	591
San Andres Formations, Pre-, of Southeastern New Mexico, Stratigraphy and Oil Producing Zones of. By Robert E. King. Review by E. Russell Lloyd	278
San Joaquin Valley, West Border of, California, Mineralogy of Late Upper Cretaceous, Paleocene, and Eocene Sandstones of Los Banos District. By S. N. Daviess	63
San Jose and Puente Hills, California, Miocene Conglomerates of. By A. O. Woodford, T. G. Moran, and J. S. Shelton	514
San Pedro Oil Field, Province of Salta, Northern Argentina. By Lyman C. Reed	591
Sandidge, John R. Expanding Activities of Paleontologists	1088
Sands, Asphaltic, Found to Occur in Oil Fields. Geological Note by D. B. Taliaferro and K. E. Stanfield	616
Santiago Pool, Kern County, California. By Glenn W. Ledingham. Abstract	2090
Schilling, Karl Howard. Memorial by Ernest G. Robinson	1969
Scholar, The, and the Future of the Research Library, a Problem and Its Solution. By Fremont Rider. Review by Marcus A. Hanna	1592
Schroeder, W. C. Abstract	741
Science Legislation and Geology. By Carey Croneis	1104
Scott, Gayle. Report of Editor. The Association Round Table	774
Scott, Harold W. Distinguished Lecture Tour. At Home and Abroad	301
Scrafford, Bruce. Development in South Texas in 1945	972
Schuppli, H. M. Oil Basins of East Indian Archipelago	1
Search for Oilfields in Great Britain, Geological Results of. By G. M. Lees and A. H. Taft. Review by D. A. Greig	1591
Sedgwick County, Kansas, Kinderhook Dolomite of. By W. A. Ver Wiebe	1747
Selected Well Logs of Colorado. By Clark F. Barb	282
Selective Service Local Board Memorandum 115. Subject: Occupational Classification Other than Agriculture and Merchant Marine. By Lewis B. Hershey. The Association Round Table	142
Selective Service Local Board Memorandum 115-M. Subject: Special Consideration for Certain Students, Teachers, and Research Workers in Physical Sciences. By Lewis B. Hershey. The Association Round Table	144
Selective Service Act Extended. The Association Round Table	1064
Self, S. R., Allison, A. P., Beckelhymer, R. L., Benson, Don G., Hutchins, R. M., Jr., Lake, C. L., Lewis, Ray C., O'Bannon, P. H., and Warner, C. A. Geology of Katy Field, Waller, Harris, and Fort Bend Counties, Texas	157
Sellards, Elias Howard—Honorary Member. By M. G. Cheney. The Association Round Table	735
Service, Geologists' Place in. By Paul H. Price	1115
Shearer, Harold Kurtz. Memorial by J. E. Brantly	1315
Sheets, Martin M. Abstract	745
Shelby, T. H., Jr., and Loetterle, G. J. Developments in East Texas during 1945	980
Shelby, T. H., Wendlandt, E. A., and Bell, John. Abstract	746
Shelby, T. H., Jr., Wendlandt, E. A., and Bell, John S. Hawkins Field, Wood County, Texas	1830
Shelton, J. S., Woodford, A. O., and Moran, T. G. Miocene Conglomerates of Puente and San Jose Hills, California	514
Shelton, John S. Abstract	2088
Sheppard, C. W., and Whitehead, W. L. Formation of Hydrocarbons from Fatty Acids by Alpha-Particle Bombardment	32
Shepard, Francis P. Abstract	2088
Shroeder, F. R., and Storey, J. B. Abstract	1967
Siluro-Devonian Strata in Central Kansas. By Hall Taylor	1221
Sinai (Egypt), Conodonts from Triassic of. Geological Note by D. B. Eicher	613
Skinner, John W. Correlation of Permian of West Texas and Southeast New Mexico	1857
Sloss, L. L., and Cooke, S. R. B. Abstract	749
—, Spectrochemical Sample Logging of Limestones	1888
Sloss, Laurence L., and Laird, Wilson M. Abstract	751

Slumping, Submarine, and Location of Oil Bodies. By Rhodes W. Fairbridge	84
Smith, Robert Hendee. Memorial by Benjamin A. Tator	1214
Society of Economic Paleontologists and Mineralogists, Titles of Papers on Program, Joint Annual Meeting, 1946	752
Society of Exploration Geophysicists, Titles of Papers on Program, Joint Annual Meeting, 1946	754
Some Developments in Aerial Photography during the War. Geological Note by L. E. Nugent, Jr.	725
Sonora, Northwest, Mexico, Stratigraphy Near Caborca. Geological Note by G. Arthur Cooper and Alberto R. V. Arellano	606
South America, Northwestern, Tectonic Framework of. By Fritz E. von Estorff. Discussion by Victor Oppenheim	1589
—, Northwestern, Tectonic Framework of. By Fritz E. von Estorff	581
South American Petroleum Congress, First. At Home and Abroad	1219
South Arkansas and North Louisiana, Developments in 1945. By William S. Hoffmeister and Van Daniel Robinson	1007
South Texas, Development in 1945. By Bruce Scrafford	972
Southeastern New Mexico, Stratigraphy and Oil Producing Zones of Pre-San Andres Formations of. By Robert E. King. Review by E. Russell Lloyd	278
Southeastern Peru, Geological Reconnaissance in. By Victor Oppenheim	254
Southeastern States, Developments in 1945. By C. W. Alexander	1020
Specific Geological Material:—State and Province in Area	1337
Spectrochemical Sample Logging of Limestones. By L. L. Sloss and S. R. B. Cooke. Abstract	749, 1888
Spivey, R. C., and Roberts, T. G. Lower Pennsylvanian Terminology in Central Texas	181
Stanfield, K. E., and Taliaferro, D. B. Asphaltic Sands Found to Occur in Oil Fields. Geological Note	616
Statistics of Exploratory Drilling, 1945. By Frederic H. Lahee. Abstract	749
Statistics of Exploratory Drilling in 1945. By Frederic H. Lahee	813
Statistics of Exploratory Drilling. Discussion by W. J. Dixon and R. M. Swesnik	2035
Status of German Oil Fields. By Frank Reeves	1546
Status of Micropaleontology in the East Gulf Region. By Henry V. Howe. Abstract	1065
Steig, M. H. Memorial of William Palen Conway, Jr.	463
Stephenson, Lloyd W. Alunite at Woodbine-Eagle Ford Contact in Northeastern Texas. Geological Note	1764
—, Rowell Well No. 1, Heidelberg Field, Mississippi. Discussion	275
Stille, Hans. Geotectonic Subdivisions of Earth History. Review by W. A. Ver Wiebe	1200
—, Tectonic Development of the Americas to Form the East Rim of the Pacific. Review by W. A. Ver Wiebe	1054
Stirton, R. A. First Oligocene Mammalian Fauna from Northern South America. Abstract. The Association Round Table	131
Stock, Chester. Memorial of Bruce Lawrence Clark	1065
Stone, Robert W. Review of Marine Microbiology, by Claude E. Zobell	1308
Storey, J. B., and Shroeder, F. R. Abstract	1967
Stow, Marcellus H. Abstract	751
Straley, H. W., III, and Dickerson, Roy E. Suggestions for Naming Multiple Sands. Geological Note	115
Stratigraphic and Structural Features of the Ivanpah Quadrangle, Southeastern California. By D. F. Hewett. Abstract	2091
Stratigraphic Section East of Bogota, Colombia. By Thomas Clements. Abstract. The Association Round Table	130
Stratigraphic Sequences, "Jacob Staff" and Measurements of. Geological Note by J. A. Broggi	716, 1934
Stratigraphy and Petroleum Geology of Black Warrior Basin, Mississippi and Alabama. By F. F. Mellen. Abstract	1963
—, of the Golden-Morrison Area, Jefferson County, Colorado. By L. W. LeRoy	1055
—, Late Paleozoic and Early Mesozoic, of Unita Mountains, Utah. By Horace D. Thomas and Max L. Krueger	1255
—, near Caborca, Northwest Sonora, Mexico. Geological Note by G. Arthur Cooper and Alberto R. V. Arellano	606
—, of the Pennsylvanian, in the West Half of Colorado and in Adjacent Parts of New Mexico. By Lloyd G. Henbest. Abstract	750
—, of Upper Nehalem River Basin, Northwestern Oregon. By W. C. Warren and Hans Norbistrath	213

— of Waller and Harris Counties, Texas. By R. L. Beckelhymer	52
—, Pre-Selma Upper Cretaceous, of Western Alabama. By Watson H. Monroe, Louis C. Conant, and D. Hoye Eargle	187
Stratigraphy and Oil Producing Zones of Pre-San Andres Formations of Southeastern New Mexico. By Robert E. King. Review by E. Russell Lloyd	278
Student Awards, Houston Geological Society. The Association Round Table	1210
Student Merit Awards, Houston Geological Society. At Home and Abroad	1069
Studies on Redox Potential of Marine Sediments. By Claude E. ZoBell	477
Subdivisions, Geotectonic, of Earth History. By Hans Stille. Review by W. A. Ver Wiebe	1200
Submarine Sedimentary Features on the Bahama Banks and Their Bearing on Distribution Patterns of Lenticular Oil Sands. By John L. Rich. Abstract	743
Submarine Slumping and Location of Oil Bodies. By Rhodes W. Fairbridge	84
Subsurface Correlations of East Texas, North Louisiana, South Arkansas, and Mississippi. By Roy T. Hazzard. Abstract	1966
Subsurface Formation, New Mississippian, in Southeast Nebraska, Boice Shale. Geological Note by E. C. Reed	348
Subsurface Occurrence of Cretaceous Sediments of Mississippi. By C. W. Alexander and R. M. Harris. Abstract	1964
Subsurface Paleozoic Stratigraphy of Southeastern Colorado. By John C. Maher. Abstract	752
Suggestions for Naming Multiple Sands. Geological Note by Roy E. Dickerson and H. W. Staley, III	115
Surface Occurrence of Cretaceous Beds in the Southeastern States. By Watson H. Monroe. Abstract	1963
Survey of College Students Majoring in Geology. Research Note by A. I. Levorsen	730
— of Weathering Processes and Products. By Parry Reiche. Review by Ronald DeFord	280
Suter, H. H. Relations between Kinds of Well Data and Apparent Faulting. Geological Note	1910
Sutton, F. A. Abstract	744
—, Geology of Maracaibo Basin, Venezuela	1621
Swensnik, R. M., and Dixon, W. J. Statistics of Exploratory Drilling. Discussion	2035
Synthetic Oil and Gasoline Industry of Germany. By W. C. Schroeder. Abstract	741
Tait, Samuel W., Jr. The Wildcatters. Review by Edward A. Koester	1308
Taitt, A. H., and Lees, G. M. Geological Results of Search for Oilfields in Great Britain. Review by D. A. Greig	1591
Taliaferro, D. B., and Stanfield, K. E. Asphaltic Sands Found to Occur in Oil Fields. Geological Note	616
Taliaferro, N. L., and Barbat, W. F. Notes on Geology of Deep Coles Levee Well, Kern County, California. Abstract. The Association Round Table	132
Tasman, Cevat E. Harbolite: A Carbonaceous Hydrocarbon. Geological Note	1051
Tator, Benjamin A. Memorial of Robert Hendee Smith	1214
Taylor, Hall. Siluro-Devonian Strata in Central Kansas	1221
Tectonic Development of the Americas to Form the East Rim of the Pacific. By Hans Stille. Review by W. A. Ver Wiebe	1054
Tectonic Features of the Greater Antilles. By Howard A. Meyerhoff. Abstract	744
— of Western Canada. By Theodore A. Link. Abstract	747
Tectonic Framework of Northwestern South America. By Fritz E. von Estorff	581
—, Discussion by Victor Oppenheim	1589
—, Discussion by Fritz E. von Estorff	2040
Tectonic Maps and Tectonic Provinces of United States. By Chester R. Longwell. Abstract	742
Tectonics, Report of Sub-Committee on. By Philip B. King	2042
Tectonics and Oil-Field Papers. Abstracts	745
Tennessee, Northeast, and Southwest Virginia, Lower Middle Ordovician of. By Chilton E. Prouty	1140
Terminology, Lower Pennsylvanian, in Central Texas. By R. C. Spivey and T. G. Roberts	181
Terrestrial Dynamics. By Bailey Willis. Abstract. The Association Round Table	133
Texas, Central, Lower Pennsylvanian Terminology in. By R. C. Spivey and T. G. Roberts	181
—, Devonian (?) Producing Zone, TXL Pool, Ector County. Geological Note by Max David	118
—, Geology of Katy Field, Waller, Harris, and Fort Bend Counties. By A. P. Allison, R. L. Beckelhymer, Don G. Benson, R. M. Hutchins, Jr., C. L. Lake, Ray C. Lewis, P. H. O'Bannon, S. R. Self, and C. A. Warner	157
—, Hawkins Field, Wood County. By E. A. Wendlandt, T. H. Shelby, Jr., and John S. Bell	1830

History of Reserves and Production of Natural Gas and Natural Gas Liquids in. By Perry Olcott	1123
North and West-Central, Developments in 1945. By North Texas Geological Society	963
Northeastern, Alunite at Woodbine-Eagle Ford Contact in. Geological Note by L. W. Stephenson	1764
Raccoon Bend Salt Dome, Austin County. Geological Note by H. J. McLellan	1306
South, Development in 1945. By Bruce Scrafford	972
Stratigraphy of Waller and Harris Counties. By R. L. Beckelhymer	52
Upper Gulf Coast of, Developments in 1945. By Donald M. Davis and Carl F. Beilharz	991
West, and Southeast New Mexico, Correlation of Permian of. By John W. Skinner	1857
Texas and New Mexico, Algae Reefs in Cap Rock of Ogallala Formation on Llano Estacado Plateau. By W. Armstrong Price, Maxim K. Elias, and John C. Frye	1742
Texas Panhandle, Developments in 1945. By Porter A. Montgomery, Jr., and Le Roy Fugitt	925
Thalmann, Hans E. Micropaleontology of Upper Cretaceous and Paleocene in Western Ecuador	337
The Association Round Table	126, 287, 357, 629, 733, 1057, 1206, 1312, 1597, 1779, 1900, 2071
Thirty-First Annual Business Meeting, Minutes. By Edward A. Koester. The Association Round Table	755
Thirty-First Annual Meeting, Chicago, April 1-4, 1946. The Association Round Table	738
Thom, W. T., Jr. Abstract	742
Thomas, C. R., Huddle, John W., and Bass, N. W. Abstract	749
Thomas, G. D. Memorial of William Francis Chisholm	1213
Thomas, Horace D., and Krueger, Max L. Late Paleozoic and Early Mesozoic Strata of the Uinta Mountains, Utah. Abstract. The Association Round Table	131
— Late Paleozoic and Early Mesozoic Stratigraphy of Uinta Mountains, Utah	1255
Tidal Waves from the Recent Aleutian Earthquake. By Francis P. Shepard. Abstract	2088
Time of Oil and Gas Accumulation. By A. I. Levorsen. Abstract	2089
Tinsley Field. By F. R. Shroeder and J. B. Storey. Abstract	1967
Titles of Papers on S.E.P.M. Program, 1946. Joint Annual Meeting	752
— of Papers on S.E.G. Program. Joint Annual Meeting, 1946	754
Tomlinson, C. W., chairman. Report of Representatives on Commission on Classification and Nomenclature of Rock Units. The Association Round Table	777
Totten, R. B., and Lloyd, A. M. Abstract	1967
Transformation of Organic Material into Petroleum. By G. M. Knebel. Abstract	748
— of Organic Material into Petroleum under Geological Conditions (The Geological Fence). By Ben B. Cox	645
Trends and Developments in Petroleum Production Engineering. By Stuart E. Buckley. Abstract	748
— since 1947. Abstracts	747
— in Petroleum Production Engineering. Stuart E. Buckley	1131
Triassic of Sinai (Egypt), Conodonts from. Geological Note by D. B. Eicher	613
Trytten, M. E. Deferment of Scientific and Technical Personnel. Office of Scientific Personnel Bulletin 26. The Association Round Table	141
Tulsa Geological Society Research Committee. Abstract	747
Twenhofel, W. H. Distinguished Lecture Tour. At Home and Abroad	807
TXL Pool, Ector County, Texas, Devonian (?) Producing Zone. Geological Note by Max David	118
Uinta Mountains, Utah, Late Paleozoic and Early Mesozoic Stratigraphy of. By Horace D. Thomas and Max L. Krueger	1255
Umbgrove, J. H. F. Evolution of Reef Corals in East Indies since Miocene Time	23
— Origin of Continental Shelves	249
— The Pulse of the Earth. Review by W. A. Ver Wiebe	278
United Kingdom, Geological Occurrence of Oil in, with References to Present Exploratory Operations. By H. R. Lovely	1444, 1959
United States Geological Survey, Recent Investigations by, of Petroleum Possibilities in Alaska. By John C. Reed	1433
Upper Cretaceous Stratigraphy, Pre-Selma, of Western Alabama. By Watson H. Monroe, Louis C. Conant, and D. Hoye Eargle	187
Upper Cretaceous and Paleocene in Western Ecuador, Micropaleontology of. By Hans E. Thalmann	337
Upper Nehalem River Basin, Northwestern Oregon, Stratigraphy of. By W. C. Warren and Hans Norbistrath	213

Uren, Lester Charles. Petroleum Production Engineering—Oil Field Development. Review by Harry H. Power	2064
Use of Geology in Southwest Pacific Area. By William C. Putnam. Abstract	741
Use of Quotation Mark in Science. Geological Note by J. E. Eaton	1928
Utah, Late Paleozoic and Early Mesozoic Stratigraphy of Uinta Mountains. By Horace D. Thomas and Max L. Krueger	1255
Valuable Geologic Tool—Grain Roundness. By Gordon Rittenhouse	1192
Van Gundy, C. E. Faulting in East Part of Grand Canyon of Arizona	1899
Van Tuyl, F. M., Levings, W. S., and Others. Review of Petroleum Geology in 1945. Review by Robert F. Walters	1955
Venezuela, Geology of Maracaibo Basin. By F. A. Sutton	1621
Ver Wiebe, W. A. Kinderhook Dolomite of Sedgwick County, Kansas	1747
Review of Geotectonic Subdivisions of Earth History, by Hans Stille	1200
Review of Tectonic Development of the Americas to Form the East Rim of the Pacific, by Hans Stille	1054
Review of The Pulse of the Earth, by J. H. F. Umbgrove	278
Review of Oil and Gas Field Development in United States, 1944, by National Oil Scouts and Landmen's Association	353
Veterans Retraining Program in Geology. By W. H. Bradley. The Association Round Table	290
Vick Formation of Pre-Tuscaloosa Age of Alabama Coastal Plain. Geological Note by Louis C. Conant	711
Virginia, Southwest, and Northeast Tennessee, Lower Middle Ordovician of. By Chilton E. Prouty	1140
von Estorff, Fritz E. Tectonic Framework of Northwestern South America	581, 2040
Discussion by Victor Oppenheim	1589
Wagner, C. M. Memorial of Frank Marion Anderson	636
Waldschmidt, W. A. Gramp's Field, Archuleta County, Colorado	561
Waldschmidt, W. A., and DeFord, Ronald K. Oilite and Oilith. Geological Note	1587
Waller and Harris Counties, Texas, Stratigraphy of. By R. L. Beckelhymer	52
Waller, Harris, and Fort Bend Counties, Texas, Geology of Katy Field. By A. P. Allison, R. L. Beckelhymer, Don G. Benson, R. M. Hutchins, Jr., C. L. Lake, Ray C. Lewis, P. H. O'Bannon, S. R. Self, and C. A. Warner	157
Walters, Ray P. Oil Fields of Carpathian Region	319
Walters, Robert F. Buried Pre-Cambrian Hills in Northeastern Barton County, Central Kansas	660
Review of Review of Petroleum Geology in 1945, by F. M. Van Tuyl, W. S. Levings, and Others	1950
Walton, Paul T. Ellis, Amsden, and Big Snowy Group, Judith Basin, Montana	1294
War, Some Developments in Aerial Photography during. Geological Note by L. E. Nugent, Jr.	725
Warner, C. A., Allison, A. P., Beckelhymer, R. L., Benson, Don G., Hutchins, R. M., Jr., Lake, C. L., O'Bannon, P. H., Lewis, Ray C., and Self, S. R. Geology of Katy Field, Waller, Harris, and Fort Bend Counties, Texas	157
Warren, W. C., and Norbistrath, Hans. Stratigraphy of Upper Nehalem River Basin, Northwestern Oregon	213
Weathering Processes and Products, Survey of. By Parry Reiche. Review by Donald K. DeFord	280
Weaver, Paul. Abstract	1965
Well Logs of Colorado, Selected. By Clark F. Barb. Review	282
Wendlandt, E. A., Shelby, T. H., and Bell, John. Abstract	746
Hawkins Field, Wood County, Texas	1830
Well Data, Relations between Kinds of, and Apparent Faulting. Geological Note by H. H. Suter	1910
West Border of San Joaquin Valley, California, Mineralogy of Late Upper Cretaceous, Paleocene, and Eocene Sandstones of Los Banos District. By S. N. Daviess	63
West-Central and North Texas, Developments in 1945. By North Texas Geological Society	963
West Edmond Oil Field, Central Oklahoma. By D. A. McGee and H. D. Jenkins	1797
West Edmond Oil Field, Oklahoma. By D. A. McGee. Abstract	746
West Texas Geological Society Field Trip, November 2 and 3, 1946. The Association Round Table	1785
West Texas and Southeast New Mexico, Correlation of Permian of. By John W. Skinner	1857
West Texas and Southeastern New Mexico, Developments in 1945. By E. Hazen Woods, C. L. Chase, and J. E. Bucher	930

West Virginia Geological Survey Collection of Drill Cuttings. Geological Note by James H. C. Martens	350
Western Alabama, Pre-Selma Upper Cretaceous Stratigraphy of. By Watson H. Monroe, Louis C. Conant, and D. Hoye Eargle	187
Western Ecuador, Micropaleontology of Upper Cretaceous and Paleocene in. By Hans E. Thalmann	337
Wharton, Jay B., and Bates, Fred W. Abstract	1966
Wharton, Jay B., Jr., and Bates, Fred W. Developments in Gulf Coast of Louisiana in 1945	999
Wheeler, Robert R. Elmore Embayment, Garvin County, Oklahoma. Geological Note	2034
Whitehead, W. L., and Sheppard, C. W., Formation of Hydrocarbons from Fatty Acids by Alpha-Particle Bombardment	32
Wildcatters, The. By Samuel W. Tait, Jr. Review by Edward A. Koester	1308
Williams, Howell, Graton, L. C., and Dorf, Erling. Paracutin Volcano, Mexico. Review by John L. Ferguson	121
Willis, Bailey. Normal Fault Structures and Others	1875
———. Terrestrial Dynamics. Abstract. The Association Round Table	133
Wilson, John H. Memorial of John Muro Golden	1970
Wood County, Texas, Hawkins Field. By E. A. Wendlandt, T. H. Shelby, Jr., and John S. Bell	1830
Woodbine-Eagle Ford Contact in Northeastern Texas, Alunite at. Geological Note by L. W. Stephenson	1764
Woodford, A. O., Moran, T. G., and Shelton, J. S. Miocene Conglomerates of Puente and San Jose Hills, California	514
Woods, E. Hazen, Chase, C. L., and Bucher, J. E. Developments in West Texas and Southeastern New Mexico in 1945	930
Woolnough, W. G. Distribution of Oceans and Continents	1981
Zebal, George. Abstract	1967
ZoBell, Claude E. Marine Microbiology. Review by Robert W. Stone	1308
———. Studies on Redox Potential of Marine Sediments	477
Zuloaga, G. Preparation of Lantern Slides. Geological Note	1771

AVAILABLE PUBLICATIONS OF

The American Association of Petroleum Geologists

Box 979, Tulsa 1, Oklahoma

-
- 1931 **Geologic Map of Cuba.** Compiled by J. Whitney Lewis. Folded paper sheet, 24 x 10 inches. Scale, 3/16 inch = 10 miles. Geologic column on same sheet. From Lewis' "Geology of Cuba," in June, 1932, *Bulletin* \$.25
- 1936 **Geology of the Tampico Region, Mexico.** By John M. Muir. 280 pp., 15 half-tone plates, 41 line drawings, 9 tables. 6 x 9 inches. Cloth. To members and associates, \$3.50 4.50
- 1936 **Areal and Tectonic Map of Southern California.** By R. D. Reed and J. S. Hollister. In 10 colors. From "Structural Evolution of Southern California," December, 1936, *Bulletin*. Scale, 1/8 inch = 1 mile. Map and 4 structure sections on strong ledger paper, 27 x 31 inches, rolled in tube50
- 1938 **Miocene Stratigraphy of California.** By Robert M. Kleinpell. 450 pp.; 14 line drawings, including a large correlation chart; 22 full-tone plates of foraminifera; 18 tables (check lists and a range chart of 15 pages). 6 x 9 inches. Cloth. To members and associates, \$4.50 5.00
- 1941 **Stratigraphic Type Oil Fields.** Symposium of 37 papers by 52 authors. 902 pp., 300 illus., 227 references in annotated bibliography. 6 x 9 inches. Cloth. To members and associates, \$4.50 5.50
- 1944 **Tectonic Map of the United States.** Prepared under the direction of the Committee on Tectonics, Division of Geology and Geography, National Research Council. Scale, 1 inch = 40 miles. Printed in 7 colors on 2 sheets, each 40 x 50 inches. Folded, \$1.75. Rolled in tube 2.00
- 1947 **Possible Future Oil Provinces of the United States and Canada.** Third printing. From August, 1941, *Bulletin*. 154 pp., 83 figs. 6 x 9 inches. Paper. To members and associates, \$1.00 1.50

Bulletin of The American Association of Petroleum Geologists. Official monthly publication. Each number, approximately 150 pages of articles, maps, discussions, reviews. Annual subscription, \$15.00 (outside United States, \$15.40). Descriptive price list of back numbers on request.

(Prices, postpaid. Write for discount to colleges and public libraries.)

BULLETIN
of the
AMERICAN ASSOCIATION OF
PETROLEUM GEOLOGISTS

GAYLE SCOTT, *Editor*

TEXAS CHRISTIAN UNIVERSITY, FORT WORTH 9, TEXAS

ASSOCIATE EDITORS

GENERAL

APPALACHIANS
NORTH CENTRAL STATES
KANSAS

OKLAHOMA
Western
Eastern

TEXAS
North and Central
Northeastern
San Antonio
Permian Basin

GULF COAST

EASTERN GULF
ARKANSAS AND NORTH LOUISIANA
ROCKY MOUNTAINS
CALIFORNIA

CANADA
SOUTH AMERICA

K. C. HEALD, Gulf Oil Corporation, Box 1166, Pittsburgh 30, Pa.
HUGH D. MISER, U. S. Geological Survey, Washington 25, D. C.
THERON WASSON, Pure Oil Company, 35 E. Wacker Drive, Chicago 1, Ill.
RICHARD E. SHERRILL, University of Pittsburgh, Pittsburgh 13, Pa.
R. B. NEWCOMBE, Superior Oil Company, Grand Rapids, Mich.
EDWARD A. KOESTER, Darby and Bothwell, Inc., Wichita 2, Kan.

ROBERT H. DOTT, Oklahoma Geological Survey, Norman, Okla.
SHERWOOD BUCKSTAFF, Shell Oil Company, Inc., Box 1191, Tulsa 2, Okla.

J. B. LOVEJOY, Gulf Oil Corporation, Fort Worth 1, Tex.
C. I. ALEXANDER, Magnolia Petroleum Company, Tyler, Tex.
JOHN R. SANDIDGE, Magnolia Petroleum Company, San Antonio 5, Tex.
E. RUSSELL LLOYD, Box 1026, Midland, Tex.
SIDNEY A. JUDSON, Texas Gulf Producing Company, Houston 1, Tex.
MARCUS A. HANNA, Gulf Oil Corporation, Houston 1, Tex.
HENRY N. TOLER, Southern Natural Gas Company, Jackson, Miss.
ROY T. HAZZARD, Gulf Refining Company of Louisiana, Shreveport 93, La.
A. E. BRAINERD, Continental Oil Company, Denver 2, Colo.
W. D. KLEINPELL, Box 1131, Bakersfield, Calif.
E. R. ATWILL, Union Oil Company of California, 617 W. 7th, Los Angeles 14
THEODORE A. LINK, Imperial Oil, Ltd., Toronto, Ontario
HOLLIS D. HEDBERG, Mene Grande Oil Co., Apt. 709, Caracas, Venezuela

VOLUME 30
JANUARY—DECEMBER 1946

PART I
PAGES 1-1076

ASSOCIATION HEADQUARTERS, BOX 979, TULSA 1, OKLAHOMA

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS, INC.

OFFICERS FOR THE YEAR ENDING MARCH, 1947

EARL B. NOBLE, *President*

Los Angeles, Calif.

EDWARD A. KOESTER, *Secretary-Treasurer*

Wichita, Kansas

D. PERRY OLCOTT, *Vice-President*

Houston, Texas

GAYLE SCOTT, *Editor*

Fort Worth, Texas

(The foregoing officers, together with the *Past-President*, MONROE G. CHENEY, Coleman, Texas, constitute the Executive Committee)

DISTRICT REPRESENTATIVES

(Representatives' terms expire immediately after annual meetings of the years shown in parentheses)

Amarillo

Elisha A. Paschal (1948), Amarillo, Tex.

Appalachians

W. O. Ziebold (1947), Charleston, W. Va.

Canada

Edwin H. Hunt (1947), Calgary, Alberta

Capital

Carle H. Dane (1948), Washington, D. C.

Corpus Christi

Ira H. Stein (1947), Alice, Tex.

Dallas

W. Dow Hamm (1948), Dallas, Tex.

East Oklahoma

J. L. Borden (1947), Tulsa

Glenn D. Hawkins (1947), Tulsa

Frank R. Clark (1948), Tulsa

Robert L. Kidd (1948), Bartlesville

Fort Worth

Lynn K. Lee (1947), Fort Worth, Tex.

Great Lakes

Robert M. English (1947), Mattoon, Ill.

Stanley G. Elder (1948), Evansville, Ind.

Houston

A. P. Allison (1947), Houston, Tex.

P. B. Leavenworth (1947), Houston, Tex.

Ira H. Brinkerhoff (1948), Houston, Tex.

Shirley L. Mason (1948), Houston, Tex.

P. H. O'Bannon (1948), Houston, Tex.

Michigan

E. J. Baltrusaitis (1947), Saginaw

New Mexico

Georges Vorbe (1947), Socorro

New York

Gail F. Moulton (1947), New York City

Pacific Coast

Rollin Eckis (1947), Bakersfield, Calif.

Glenn C. Ferguson (1947), Bakersfield, Calif.

Frank W. Bell (1948), Sacramento, Calif.

Claude E. Leach (1948), Ventura, Calif.

D. E. Taylor (1948), Long Beach, Calif.

Rocky Mountains

Robert L. Sielaff (1947), Casper, Wyo.

H. E. Christensen (1948), Denver, Colo.

Shreveport

G. D. Thomas (1947), Shreveport, La.

South America

L. W. Henry (1947), Caracas, Venezuela

Southeast Gulf

Henry N. Toler (1947), Jackson, Miss.

Southern Louisiana

Max Bornhauser (1947), Lafayette

So. Permian Basin

George R. Gibson (1947), Midland, Tex.

Warren D. Anderson (1948), Midland, Tex.

South Texas

Adolph Dovre (1947), San Antonio

Wesley G. Gish (1948), San Antonio

Tyler

J. S. Hudnall (1947), Tyler, Tex.

West Oklahoma

Jerry B. Newby (1947), Oklahoma City

C. W. Tomlinson (1948), Ardmore

Wichita

John W. Inkster (1947), Wichita, Kan.

Wichita Falls

J. J. Russell, Jr. (1948)

DIVISION REPRESENTATIVES

Paleontology and Mineralogy

F. W. Rolshausen (1947), Houston, Tex.

Henry B. Stenzel (1947), Austin, Tex.

OFFICERS FOR THE YEAR ENDING APRIL, 1946

President: MONROE G. CHENEY

Secretary-Treasurer: EDWARD A. KOESTER

Vice-President: M. GORDON GULLEY

Editor: GAYLE SCOTT

(The foregoing officers, together with the *Past-President*, IRA H. CRAM, constitute the Executive Committee)

COPYRIGHT 1946 BY
THE AMERICAN ASSOCIATION OF
PETROLEUM GEOLOGISTS

PUBLISHED
MONTHLY

Composed and Printed by
George Banta Publishing Company
Menasha, Wisconsin, U.S.A.

CONTENTS OF VOLUME 30 (1946), PART I

NUMBER 1 (JANUARY)

Oil Basins of East Indian Archipelago, <i>H. M. Schuppli</i>	1
Evolution of Reef Corals in East Indies since Miocene Time, <i>J. H. F. Umbgrove</i>	23
Formation of Hydrocarbons from Fatty Acids by Alpha-Particle Bombardment, <i>C. W. Sheppard and W. L. Whitehead</i>	32
Stratigraphy of Waller and Harris Counties, Texas, <i>R. L. Beckelhymer</i>	52
Mineralogy of Late Upper Cretaceous, Paleocene, and Eocene Sandstones of Los Banos District, West Border of San Joaquin Valley, California, <i>S. N. Daviss</i>	63
Submarine Slumping and Location of Oil Bodies, <i>Rhodes W. Fairbridge</i>	84
Conodonts as Paleozoic Guide Fossils, <i>Samuel P. Ellison, Jr.</i>	93
GEOLOGICAL NOTES	
Outline for Classification of Oil Possibilities, <i>Frank Reeves</i>	111
Suggestion for Naming Multiple Sands, <i>Roy E. Dickerson and H. W. Straley, III</i>	115
Devonian(?) Producing Zone, TXL Pool, Ector County, Texas, <i>Max David</i>	118
Natural Resources Section in Japan and Korea, <i>Thomas A. Hendricks</i>	119
REVIEWS AND NEW PUBLICATIONS	120
THE ASSOCIATION ROUND TABLE	126
AT HOME AND ABROAD	147

NUMBER 2 (FEBRUARY)

Geology of Katy Field, Waller, Harris, and Fort Bend Counties, Texas, <i>A. P. Allison, R. L. Beckelhymer, Don G. Benson, R. M. Hutchins, Jr., C. L. Lake, Ray C. Lewis, P. H. O'Bannon, S. R. Self and C. A. Warner</i>	157
Lower Pennsylvanian Terminology in Central Texas, <i>R. C. Spivey and T. G. Roberts</i>	181
Pre-Selma Upper Cretaceous Stratigraphy of Western Alabama, <i>Watson H. Monroe, Louis C. Conant, and D. Hoyer Eargle</i>	187
Stratigraphy of Upper Nehalem River Basin, Northwestern Oregon, <i>W. C. Warren and Hans Norbistrath</i>	213
Fossil Plants and Jurassic-Cretaceous Boundary in Montana and Alberta, <i>Roland W. Brown</i>	238
Origin of Continental Shelves, <i>J. H. F. Umbgrove</i>	249
Geological Reconnaissance in Southeastern Peru, <i>Victor Oppenheim</i>	254
RESEARCH NOTES	
Interim Report of Research Committee, <i>S. W. Lowman</i>	265
DISCUSSION	275
REVIEWS AND NEW PUBLICATIONS	278
THE ASSOCIATION ROUND TABLE	287
MEMORIAL	
Alexander Watts McCoy, <i>The Executive Committee</i>	292
AT HOME AND ABROAD	297

NUMBER 3 (MARCH)

Porosity through Dolomitization, <i>Kenneth K. Landes</i>	305
Oil Fields of Carpathian Region, <i>Ray P. Walters</i>	319
Micropaleontology of Upper Cretaceous and Paleocene in Western Ecuador, <i>Hans E. Thalmann</i>	337
GEOLOGICAL NOTES	
Boice Shale, New Mississippian Subsurface Formation in Southeast Nebraska, <i>E. C. Reed</i>	348
West Virginia Geological Survey Collection of Drill Cuttings, <i>James H. Martens</i>	350
REVIEWS AND NEW PUBLICATIONS	353
THE ASSOCIATION ROUND TABLE	
Association Membership List, March 2, 1946	361
Financial Statement for 1945	455
MEMORIAL	
William Palen Conway, Jr., <i>M. H. Steig</i>	463
Roy Jay Holden, <i>Heath M. Robinson</i>	464
Donald Egbert Fuellhart, <i>Dugald Gordon</i>	468
AT HOME AND ABROAD	470

NUMBER 4 (APRIL)

Studies on Redox Potential of Marine Sediments, <i>Claude E. ZoBell</i>	477
Miocene Conglomerates of Puente and San Jose Hills, California, <i>A. O. Woodford, T. G. Moran, and J. S. Shelton</i>	514
Gramp's Field, Archuleta County, Colorado, <i>W. A. Waldschmidt</i>	561
Tectonic Framework of Northwestern South America, <i>Fritz E. von Estorff</i>	581
San Pedro Oil Field, Province of Salta, Northern Argentina, <i>Lyman C. Reed</i>	591

GEOLOGICAL NOTES

Stratigraphy near Caborca, Northwest Sonora, Mexico, <i>G. Arthur Cooper and Alberto R. V. Arellano</i>	606
Age of Penters Chert, Batesville District, Arkansas, <i>Douglas M. Kinney</i>	611
Conodonts from Triassic of Sinai (Egypt), <i>D. B. Eicher</i>	613
Asphaltic Sands Found to Occur in Oil Fields, <i>D. B. Taltiaferro and K. E. Stansfield</i>	616

DISCUSSION

Photography of Megafossils, <i>Floyd K. Beach</i>	620
---	-----

REVIEWS AND NEW PUBLICATIONS

THE ASSOCIATION ROUND TABLE	625
-----------------------------	-----

MEMORIAL

Albert Foster Crider, <i>C. L. Moody</i>	633
Frank Marion Anderson, <i>C. M. Wagner</i>	636

AT HOME AND ABROAD	640
--------------------	-----

NUMBER 5 (MAY)

Transformation of Organic Material into Petroleum under Geological Conditions (The Geological Fence), <i>Ben B. Cox</i>	645
Buried Pre-Cambrian Hills in Northeastern Barton County, Central Kansas, <i>Robert F. Walters</i>	660

GEOLOGICAL NOTES

Vick Formation of Pre-Tuscaloosa Age of Alabama Coastal Plain, <i>Louis C. Conant</i>	711
"Jacob Staff" and Measurements of Stratigraphic Sequences, <i>J. A. Broggi</i>	716
Some Developments in Aerial Photography during the War, <i>L. E. Nugent, Jr.</i>	725

RESEARCH NOTES

Survey of College Students Majoring in Geology, <i>A. I. Levorsen</i>	730
---	-----

REVIEWS AND NEW PUBLICATIONS

THE ASSOCIATION ROUND TABLE	731
-----------------------------	-----

Minutes, Thirty-First Annual Meeting, <i>Edward A. Koester</i>	755
--	-----

MEMORIAL

The Geologist in World War II—A Memorial, <i>A. Rodger Denison</i>	802
Robert W. Burger, <i>Rollin Eckis</i>	803
Kenneth Mason Bravinder, <i>Gilbert T. Bowen</i>	805

AT HOME AND ABROAD	807
--------------------	-----

NUMBER 6 (JUNE)

REVIEW OF EXPLORATION AND DEVELOPMENT IN 1945

Statistics of Exploratory Drilling in 1945, <i>Frederic H. Lahee</i>	813
California, <i>Graham B. Moody</i>	820
Canada, <i>George S. Hume</i>	851
Appalachians, <i>Appalachian Geological Society</i>	861
Eastern Interior, <i>Alfred H. Bell</i>	879
Michigan, <i>H. J. Hardenberg</i>	886
North Mid-Continent, <i>Virgil B. Cole and Edward A. Koester</i>	895
Oklahoma, <i>Joseph L. Borden</i>	902
Rocky Mountains, <i>E. W. Krampert</i>	912
Texas Panhandle, <i>Porter A. Montgomery, Jr. and Le Roy Fugitt</i>	925
West Texas and Southeastern New Mexico, <i>E. Hazen Woods, C. L. Chase, and J. E. Bucher</i>	930
Arizona, Western and Northern New Mexico, <i>Robert L. Bates</i>	958
North and West-Central Texas, <i>North Texas Geological Society</i>	963
South Texas, <i>Bruce Scraftord</i>	972
East Texas, <i>T. H. Shelby, Jr., and G. J. Loetterle</i>	980
Upper Gulf Coast of Texas, <i>Donald M. Davis and Carl F. Beilhars</i>	991
Louisiana Gulf Coast, <i>Fred W. Bates and Jay B. Wharton, Jr.</i>	999
South Arkansas and North Louisiana, <i>William S. Hoffmeister and Van Daniel Robinson</i>	1007
Southeastern States, <i>C. W. Alexander</i>	1020

GEOLOGICAL NOTES

Harbolite: A Carbonaceous Hydrocarbon, <i>Cevat E. Tasman</i>	1051
---	------

DISCUSSION

Geological Reconnaissance in Southeastern Perú, <i>H. E. Parsons</i>	1053
--	------

REVIEWS AND NEW PUBLICATIONS

THE ASSOCIATION ROUND TABLE	1054
-----------------------------	------

MEMORIAL

Bruce Lawrence Clark, <i>Chester Stock</i>	1065
Dana Hogan, <i>J. R. Pemberton</i>	1066

AT HOME AND ABROAD	1068
--------------------	------

ERRATA

PAGE 717. Figure 2 should not have been used. The correct Figure 2 is printed on page 1934.

BULLETIN

of the

AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

GAYLE SCOTT, *Editor*
TEXAS CHRISTIAN UNIVERSITY, FORT WORTH 9, TEXAS

ASSOCIATE EDITORS

GENERAL

APPALACHIANS

NORTH CENTRAL STATES

KANSAS

OKLAHOMA

Western

Eastern

TEXAS

North and Central

Northeastern

San Antonio

Permian Basin

GULF COAST

EASTERN GULF

ARKANSAS AND NORTH LOUISIANA

ROCKY MOUNTAINS

CALIFORNIA

CANADA

SOUTH AMERICA

K. C. HEALD, Gulf Oil Corporation, Box 1166, Pittsburgh 30, Pa.
HUGH D. MISER, U. S. Geological Survey, Washington 25, D. C.
THERON WASSON, Pure Oil Company, 35 E. Wacker Drive, Chicago 1, Ill.
RICHARD E. SHERRILL, University of Pittsburgh, Pittsburgh 13, Pa.
R. B. NEWCOMBE, Superior Oil Company, Grand Rapids, Mich.
EDWARD A. KOESTER, Darby and Bothwell, Inc., Wichita 2, Kan.

ROBERT H. DOTT, Oklahoma Geological Survey, Norman, Okla.
SHERWOOD BUCKSTAFF, Shell Oil Company, Inc., Box 1191, Tulsa 2, Okla.

J. B. LOVEJOY, Gulf Oil Corporation, Fort Worth 1, Tex.
C. I. ALEXANDER, Magnolia Petroleum Company, Tyler, Tex.
JOHN R. SANDIDGE, Magnolia Petroleum Company, San Antonio 5, Tex.
E. RUSSELL LLOYD, Box 1026, Midland, Tex.
SIDNEY A. JUDSON, Texas Gulf Producing Company, Houston 1, Tex.
MARCUS A. HANNA, Gulf Oil Corporation, Houston 1, Tex.
HENRY N. TOLER, Southern Natural Gas Company, Jackson, Miss.
ROY T. HAZZARD, Gulf Refining Company of Louisiana, Shreveport 93, La.
A. E. BRAINERD, Continental Oil Company, Denver 2, Colo.
W. D. KLEINPELL, Box 1131, Bakersfield, Calif.
E. R. ATWILL, Union Oil Company of California, 617 W. 7th, Los Angeles 14
THEODORE A. LINK, Imperial Oil, Ltd., Calgary, Alberta
HOLLIS D. HEDBERG, Mene Grande Oil Co., Apt. 709, Caracas, Venezuela

VOLUME 30

JANUARY—DECEMBER 1946

PART II

PAGES 1077-2120

ASSOCIATION HEADQUARTERS, BOX 979, TULSA 1, OKLAHOMA

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS, INC.

OFFICERS FOR THE YEAR ENDING MARCH, 1947

EARL B. NOBLE, *President*
Los Angeles, California
EDWARD A. KOESTER, *Secretary-Treasurer*
Wichita, Kansas

D. PERRY OLCOTT, *Vice-President*
Houston, Texas
GAYLE SCOTT, *Editor*
Fort Worth, Texas

(The foregoing officers, together with the *Past-President*, MONROE G. CHENEY, Coleman, Texas, constitute the Executive Committee)

DISTRICT REPRESENTATIVES

(Representatives' terms expire immediately after annual meetings of the years shown in parentheses)

Amarillo Elisha A. Paschal (1948), Amarillo, Tex.	New York Gail F. Moulton (1947), New York City
Appalachians W. O. Ziebold (1947), Charleston, W. Va.	Pacific Coast Rollin Eckis (1947), Bakersfield, Calif.
Canada Edwin H. Hunt (1947), Calgary, Alberta	Glenn C. Ferguson (1947), Bakersfield, Calif.
Capital Carle H. Dane (1948), Washington, D. C.	Frank W. Bell (1948), Sacramento, Calif.
Corpus Christi Ira H. Stein (1947), Alice, Tex.	Claude E. Leach (1948), Ventura, Calif.
Dallas W. Dow Hamm (1948), Dallas, Tex.	D. E. Taylor (1948), Long Beach, Calif.
East Oklahoma J. L. Borden (1947), Tulsa	Rocky Mountains Robert L. Sielaff (1947), Casper, Wyo.
Glenn D. Hawkins (1947), Tulsa	H. E. Christensen (1948), Denver, Colo.
Frank R. Clark (1948), Tulsa	Shreveport G. D. Thomas (1947), Shreveport, La.
Robert L. Kidd (1948), Bartlesville	South America L. W. Henry (1947), Caracas, Venezuela
Fort Worth Lynn K. Lee (1947), Fort Worth, Tex.	Southeast Gulf Henry N. Toler (1947), Jackson, Miss.
Great Lakes Robert M. English (1947), Mattoon, Ill.	Southern Louisiana Max Bornhauser (1947), Lafayette
Stanley G. Elder (1948), Evansville, Ind.	So. Permian Basin George R. Gibson (1947), Midland, Tex.
Houston A. P. Allison (1947), Houston, Tex.	Warren D. Anderson (1948), Midland, Tex.
P. B. Leavenworth (1947), Houston, Tex.	South Texas Adolph Dovre (1947), San Antonio
Ira H. Brinkerhoff (1948), Houston, Tex.	Wesley G. Gish (1948), San Antonio
Shirley L. Mason (1948), Houston, Tex.	Tyler J. S. Hudnall (1947), Tyler, Tex.
P. H. O'Bannon (1948), Houston, Tex.	West Oklahoma Jerry B. Newby (1947), Oklahoma City
Michigan E. J. Baltrusaitis (1948), Saginaw	C. W. Tomlinson (1948), Ardmore
New Mexico Georges Vorbe (1947), Socorro	Wichita John W. Inkster (1947), Wichita, Kan.
	Wichita Falls J. J. Russell, Jr. (1948), Wichita Falls, Tex.

DIVISION REPRESENTATIVES

Paleontology and Mineralogy

F. W. Rolshausen (1947), Houston, Tex.

Henryk B. Stenzel (1947), Austin, Tex.

OFFICERS FOR THE YEAR ENDING APRIL, 1946

President: MONROE G. CHENEY
Secretary-Treasurer: EDWARD A. KOESTER

Vice-President: M. GORDON GULLEY
Editor: GAYLE SCOTT

(The foregoing officers, together with the *Past-President*, IRA H. CRAM, constitute the Executive Committee)

COPYRIGHT 1946 BY
THE AMERICAN ASSOCIATION OF
PETROLEUM GEOLOGISTS

PUBLISHED
MONTHLY

Composed and Printed by
George Banta Publishing Company
Menasha, Wisconsin, U.S.A.

CONTENTS OF VOLUME 30 (1946), PART II

NUMBER 7 (JULY)

The Geological Attack, <i>M. G. Cheney</i>	1077
Expanding Activities of Paleontologists, <i>John R. Sandidge</i>	1088
Publication of Geophysical Case Histories, <i>Henry C. Cortes</i>	1095
Facing Forward, <i>Eugene Holman</i>	1099
Science Legislation and Geology, <i>Carey Croneis</i>	1104
Geologists' Place in Service, <i>Paul H. Price</i>	1115
History of Reserves and Production of Natural Gas and Natural Gas Liquids in Texas, <i>Peery Olcott</i>	1123
Trends and Developments in Petroleum Production Engineering, <i>Stuart E. Buckley</i>	1131
Lower Middle Ordovician of Southwest Virginia and Northeast Tennessee, <i>Chilton E. Prouty</i>	1140
Grain Roundness—A Valuable Geologic Tool, <i>Gordon Rittenhouse</i>	1192
GEOLOGICAL NOTES	
Half-Page Method of Manuscript Preparation, <i>W. Armstrong Price</i>	1198
REVIEWS AND NEW PUBLICATIONS	1200
THE ASSOCIATION ROUND TABLE	1200
MEMORIAL	
William Francis Chisholm, <i>G. D. Thomas</i>	1213
Robert Hendee Smith, <i>Benjamin A. Tator</i>	1214
AT HOME AND ABROAD	1217

NUMBER 8 (AUGUST)

(PART I)	
Siluro-Devonian Strata in Central Kansas, <i>Hall Taylor</i>	1221
Late Paleozoic and Early Mesozoic Stratigraphy of Uinta Mountains, Utah, <i>Horace D. Thomas and Max L. Krueger</i>	1255
Ellis, Amsden, and Big Snowy Group, Judith Basin, Montana, <i>Paul T. Walton</i>	1294
GEOLOGICAL NOTES	
Raccoon Bend Salt Dome, Austin County, Texas, <i>H. J. McLellan</i>	1306
REVIEWS AND NEW PUBLICATIONS	1308
THE ASSOCIATION ROUND TABLE	1312
MEMORIAL	
Harold Kurtz Shearer, <i>J. E. Brantley</i>	1315
AT HOME AND ABROAD	1318
(PART II)	
Directory of Geological Material in North America, <i>J. V. Howell and A. I. Levorsen</i>	1321

NUMBER 9 (SEPTEMBER)

Recent Investigations by United States Geological Survey of Petroleum Possibilities in Alaska, <i>John C. Reed</i>	1433
Geological Occurrence of Oil in United Kingdom, with Reference to Present Exploratory Operations, <i>H. R. Lovely</i>	1444
Petroleum Geology of Aquitaine Basin, France, <i>A. J. Eardley</i>	1517
Status of German Oil Fields, <i>Frank Reeves</i>	1546
GEOLOGICAL NOTES	
Quimbys Mill, New Member of Platteville Formation, Upper Mississippi Valley, <i>Allen F. Agnew and Allen V. Heyl, Jr.</i>	1585
Oolite and Oolite, <i>Ronald K. DeFord and W. A. Waldschmidt</i>	1587
DISCUSSION	
Tectonic Framework of Northwestern South America, by Fritz E. von Estorff, <i>Victor Oppenheim</i>	1589
REVIEWS AND NEW PUBLICATIONS	1591
THE ASSOCIATION ROUND TABLE	
Constitution and By-Laws	1600
Supplementary Membership List, September 1, 1946	1610
MEMORIAL	
Fred Burchard Ely, <i>Gail F. Moulton</i>	1616
AT HOME AND ABROAD	1617

NUMBER 10 (OCTOBER)

Geology of Maracaibo Basin, Venezuela, <i>F. A. Sutton</i>	1621
Algae Reefs in Cap Rock of Ogallala Formation on Llano Estacado Plateau, New Mexico and Texas, <i>W. Armstrong Price, Maxim K. Elias, and John C. Frye</i>	1742

Kinderhook Dolomite of Sedgwick County, Kansas, <i>W. A. Ver Wiebe</i>	1747
Correlation of Paleozoic Rocks Across Las Animas Arch in Baca, Las Animas, and Otero Counties, Colorado, <i>John C. Maher</i>	1756
GEOLOGICAL NOTES	
Alunite at Woodbine-Eagle Ford Contact in Northeastern Texas, <i>L. W. Stephenson</i>	1764
Preparation of Lantern Slides, <i>G. Zuloaga</i>	1771
REVIEWS AND NEW PUBLICATIONS	1772
THE ASSOCIATION ROUND TABLE	1779
MEMORIAL	
Otto Dreher, <i>E. A. Ritter</i>	1786
Donald Dudley Hughes, <i>Eric K. Craig</i>	1786
AT HOME AND ABROAD	1789

NUMBER 11 (NOVEMBER)

West Edmond Oil Field, Central Oklahoma, <i>D. A. McGee and H. D. Jenkins</i>	1797
Hawkins Field, Wood County, Texas, <i>E. A. Wendlandt, T. H. Shelby, Jr., and John S. Bell</i>	1830
Correlation of Permian of West Texas and Southeast New Mexico, <i>John W. Skinner</i>	1857
Normal Fault Structures and others, <i>Bailey Willis</i>	1875
Spectrochemical Sample Logging of Limestones, <i>L. L. Sloss and S. R. B. Cooke</i>	1888
Faulting in East Part of Grand Canyon of Arizona, <i>C. E. Van Gundy</i>	1899
GEOLOGICAL NOTES	
Relations between Kinds of Well Data and Apparent Faulting, <i>H. H. Suter</i>	1910
Atlantic Coastal Plain Floor and Continental Slope of North Carolina, <i>W. F. Prouty</i>	1917
Grain Size in Carbonate Rock, <i>Ronald K. DeFord</i>	1921
Use of Quotation Mark in Science, <i>J. E. Eaton</i>	1928
"Jacob Staff" and Measurements of Stratigraphic Sequences—A Correction, <i>J. A. Broggi</i>	1934
RESEARCH	
Progress Report on A.P.I. Research Project No. 43—The Transformation of Organic Material into Petroleum, <i>G. M. Knebel</i>	1935
Research Committee Calendar and Schedule, <i>S. W. Lowman and M. A. Hanna</i>	1950
REVIEWS AND NEW PUBLICATIONS	1955
THE ASSOCIATION ROUND TABLE	1960
MEMORIAL	
Karl Howard Schilling, <i>Ernest G. Robinson</i>	1969
John Muro Golden, <i>John H. Wilson</i>	1970
AT HOME AND ABROAD	1973

NUMBER 12 (DECEMBER)

Distribution of Oceans and Continents, <i>W. G. Woolnough</i>	1981
Recent Trends in Geological-Geophysical Exploration, <i>R. Clare Coffin</i>	2013
GEOLOGICAL NOTES	
Elmore Embayment, Garvin County, Oklahoma, <i>Robert R. Wheeler</i>	2034
DISCUSSION	
Statistics of Exploratory Drilling, <i>W. J. Dixon and R. M. Swesnik</i>	2035
Tectonic Framework of Northwestern South America, <i>F. E. von Estorff</i>	2040
RESEARCH	
Final Reports of a Reconnaissance Survey of Research Needs in Petroleum Geology by the American Association of Petroleum Geologists Research Committee, 1945-1946. Foreword, <i>Shepard W. Lowman</i>	2042
Report of Sub-Committee on Tectonics, <i>Philip B. King</i>	2042
REVIEWS AND NEW PUBLICATIONS	2064
THE ASSOCIATION ROUND TABLE	2071
AT HOME AND ABROAD	2092
INDEX OF VOLUME 30 (1946)	2097

ERRATA

- PAGE 1508. First center heading should be: B. JURASSIC PROSPECTS.
 Second center heading should be: C. PERMIAN, etc.
 Third center heading should be: D. LOWER CRETACEOUS, etc.
- PAGE 1512. Center heading should be: A. JURASSIC PROSPECTS.
- PAGE 1513. Center heading should be: B. CARBONIFEROUS, etc.
- PAGE 1514. First center heading should be: B. JURASSIC.
 Second center heading should be: C. PERMIAN, etc.
- PAGE 1589. Discussion should be: TECTONIC FRAMEWORK OF NORTHWESTERN SOUTH AMERICA.

PROFESSIONAL DIRECTORY

ALABAMA

HARRY R. HOSTETTER
Core Drilling Contractor
Specialist in Reverse Circulation Coring
100% Recovery
 Monroeville, Alabama
 P.O. Box 388 Tel. 39-W

CALIFORNIA

J. L. CHASE
Geologist — Geophysicist
 169 LaVerne Avenue
 LONG BEACH 3 CALIFORNIA
 Tel. 816-04
Specializing in Magnetic Surveys

VERNON L. KING
Petroleum Geologist and Engineer
 707 South Hill Street
 LOS ANGELES, CALIFORNIA
 Vandike 7087

JEROME J. O'BRIEN
Petroleum Geologist
 Examinations, Reports, Appraisals
 Petroleum Building
 714 West Olympic Boulevard
 MCLARTHY & O'BRIEN Los Angeles 15, Calif.

HENRY SALVATORI
Western Geophysical Company
 711 Edison Building
 601 West Fifth Street
 LOS ANGELES, CALIFORNIA

CALIFORNIA

H. W. BELL
Geologist and Engineer
 Consultant in Oil, Gas, Mining
 for
 Development, Production, Appraisal
 1136 Wild Rose Dr., Santa Rosa, Calif.

PAUL P. GOUDKOFF
Geologist
 Geologic Correlation by Foraminifera
 and Mineral Grains
 799 Subway Terminal Building
 LOS ANGELES, CALIFORNIA

A. I. LEVORSEN
Petroleum Geologist
 STANFORD UNIVERSITY CALIFORNIA

ERNEST K. PARKS
Consultant in
Petroleum and Natural Gas Development
and
Engineering Management
 614 S. Hope St.
 LOS ANGELES, CALIFORNIA

RICHARD L. TRIPLETT
Core Drilling Contractor
 Parkway 9925 1660 Virginia Road
 LOS ANGELES 6, CALIF.

COLORADO

L. BRUNDALL **A. R. WASEM**
 Geophoto Services, Inc.
 Photogeologists and Consulting Geologists
 Mountain States Exploration Drilling Co.
Core Drilling
 110 W. 13th Ave. DENVER, COLO.

DAN KRALIS
Consulting Geologist
 Eastern Colorado
 Surface, subsurface, sedimentation, stratigraphy,
 paleogeography, wells, reports
 Box 1813, Denver, Colorado

C. A. HEILAND
Heiland Research Corporation
 130 East Fifth Avenue
 DENVER 9, COLORADO

HARRY W. OBORNE
Geologist
 304 Mining Exchange Bldg. 230 Park Ave.
 Colorado Springs, Colo. New York, N.Y.
 Main 5663 Murray Hill 9-3541

<p style="text-align: center;">COLORADO</p> <p style="text-align: center;">EVERETT S. SHAW <i>Geologist and Engineer</i> 3131 Zenobia Street DENVER COLORADO</p>	<p style="text-align: center;">ILLINOIS</p> <p style="text-align: center;">C. E. BREHM <i>Consulting Geologist and Geophysicist</i> New Stumpp Building, Mt. Vernon, Illinois</p>
<p style="text-align: center;">ILLINOIS</p> <p style="text-align: center;">J. L. MCMANAMY <i>Consulting Geologist</i> Mt. Vernon, Illinois</p>	<p style="text-align: center;">L. A. MYLIUS <i>Geologist Engineer</i> 122A North Locust Street Box 264, Centralia, Illinois</p>
<p style="text-align: center;">T. E. WALL <i>Geologist</i> Mt. Vernon Illinois</p>	<p style="text-align: center;">INDIANA</p> <p style="text-align: center;">HARRY H. NOWLAN <i>Consulting Geologist and Engineer Specializing in Valuations</i> Evansville 19, Indiana 317 Court Bldg. Phone 2-7818</p>
KANSAS	
<p style="text-align: center;">C. ENGSTRAND <i>Detailed Lithologic Logs</i> KANSAS SAMPLE LOG SERVICE 415 N. Pershing Wichita Kansas</p>	<p style="text-align: center;">WENDELL S. JOHNS PETROLEUM GEOLOGIST Office Phone 3-1540 600 Bitting Building Res. Phone 2-7266 Wichita 2, Kansas</p>
LOUISIANA	
<p style="text-align: center;">WILLIAM M. BARRET, INC. <i>Consulting Geophysicists</i> Specializing in Magnetic Surveys Giddens-Lane Building SHREVEPORT, LA.</p>	<p style="text-align: center;">CYRIL K. MORESI <i>Consulting Geologist</i> Jeanerette, Louisiana Box 126 Phone 59 Phone 484-W</p>
<p style="text-align: center;">G. FREDERICK SHEPHERD <i>Consulting Geologist</i> 125 Maryland Drive Phone AUdubon 1403 New Orleans 18, La.</p>	<p style="text-align: center;">MISSISSIPPI</p> <p style="text-align: center;">R. Merrill Harris Willard M. Payne HARRIS & PAYNE <i>Geologists</i> 100 East Pearl-Bldg. Phone 4-6286 Jackson, Miss. or L.D. 89</p>
<p style="text-align: center;">MISSISSIPPI</p> <p style="text-align: center;">G. JEFFREYS <i>Geologist Engineer</i> Specialist, Mississippi & Alabama 100 East Pearl Street Box 2415 Depot P.O. Jackson, Mississippi</p>	<p style="text-align: center;">MELLEN & MONSOUR <i>Consulting Geologists</i> Frederic F. Mellen E. T. "Mike" Monsour Box 2571, West Jackson, Mississippi 112½ E. Capitol St. Phone 2-1368</p>

MISSISSIPPI

E. P. THOMAS

Geologist

Contract Surface Geology

767 N. Congress St.
Jackson, Miss.Phone
4-6327

NEW MEXICO

VILAS P. SHELDON

*Consulting Geologist and Reservoir
Performance Specialist*Geological Reports, Valuations, Appraisals,
Microscopic well cutting examination,
well completion supervision, reservoir
performance analysesOffice Phone 720-W Carper Building
Home Phone 702-J Artesia, New Mexico

NEW YORK

FRANK RIEBER

*Geophysicist*Specializing in the development of new
instruments and procedures

127 East 73d St.

New York 21

OHIO

JOHN L. RICH

Geologist

General Petroleum Geology

Geological Interpretation of Aerial Photographs

University of Cincinnati
Cincinnati, Ohio

OKLAHOMA

WARREN L. CALVERT

President

The American Exploration Service, Inc.

*Core and Stratigraphic Drilling
Elevation and Geologic Service*

811 Tradesmens Bank Bldg., Oklahoma City, Okla.

WALTER E. HOPPER

Geologist and Consultant

Petroleum and Natural Gas

Reports Appraisals

Estimates of Reserves

510 National Mutual Building Tulsa 3, Oklahoma

FRANK A. MELTON

*Consulting Geologist**Aerial Photographs**and Their Structural Interpretation*

1010 Chautauqua

Norman, Oklahoma

MONTANA

HERBERT D. HADLEY

Petroleum Geologist

Billings, Montana

801 Grand Ave.

Phone 2950

NEW YORK

BROKAW, DIXON & McKEE
*Geologists Engineers*OIL-NATURAL GAS
Examinations, Reports, Appraisals
Estimates of Reserves120 Broadway
New YorkGulf Building
Houston

NORTH CAROLINA

RODERICK A. STAMEY

Petroleum Geologist

109 East Gordon Street

KINSTON

NORTH CAROLINA

OKLAHOMA

ELFRED BECK

Geologist

308 Tulsa Loan Bldg.

Box 55

TULSA, OKLA.

DALLAS, TEX.

CRAIG FERRIS

Geophysicist

E. V. McCollum & Co.

1510 Thompson Bldg.

Tulsa 3, Okla.

R. W. LAUGHLIN

WELL ELEVATIONS

LAUGHLIN-SIMMONS & Co.

615 Oklahoma Building

TULSA

OKLAHOMA

CLARK MILLISON

Petroleum Geologist

Philtower Building

TULSA

OKLAHOMA

OKLAHOMA

P. B. NICHOLS
Mechanical Well Logging
 THE GEOGRAPH COMPANY
 25 Northwestern
 Oklahoma City Oklahoma

C. L. WAGNER
Consulting Geologist
Petroleum Engineering
Geophysical Surveys
 2259 South Troost St.
 TULSA OKLAHOMA

G. H. WESTBY
Geologist and Geophysicist
Seismograph Service Corporation
 Kennedy Building Tulsa, Oklahoma

JOSEPH A. SHARPE

Geophysicist

C. H. FROST GRAVIMETRIC SURVEYS, INC.
 1242 South Boston Ave. Tulsa 3, Okla.

WARE & KAPNER
 SAMPLE LOG SERVICE
Wildcat Sample Log Service
Covering Southern Oklahoma
 John M. Ware H. H. Kapner
 Tulsa, Oklahoma
 2514 South Norfolk 4-2539

PENNSYLVANIA

HUNTLEY & HUNTLEY
Petroleum Geologists
and Engineers
 Grant Building, Pittsburgh, Pa.
 L. G. HUNTLEY
 J. R. WYLIE, JR.
 JAMES F. SWAIN

TEXAS

JOSEPH L. ADLER
Geologist and Geophysicist
Contracting Geophysical Surveys
in Latin America
 Independent Exploration Company
 Esperson Building Houston, Texas

HART BROWN
 BROWN GEOPHYSICAL COMPANY
Gravity
 P.O. Box 6005 Houston 6, Texas

PAUL CHARRIN
Geologist and Geophysicist
 UNIVERSAL EXPLORATION COMPANY
 2044 Richmond Road, Houston 6, Texas
 913 Union National Bank Building
 Houston 2, Texas

CUMMINS, BERGER & PISHNY
Consulting Engineers & Geologists
 Specializing in Valuations
 1603 Commercial Standard Bldg. Fort Worth 2, Texas
 Ralph H. Cummins
 Walter R. Berger
 Chas. H. Pishny

CHESTER F. BARNES
Geologist and Geophysicist
 Petroleum Bldg. P.O. Box 266, Big Spring, Tex.

D'ARCY M. CASHIN
Geologist Engineer
Specialist Gulf Coast Salt Domes
 Examinations, Reports, Appraisals
 Estimates of Reserves
 705 Nat'l Standard Bldg.
 HOUSTON, TEXAS

LEAVITT CORNING, JR.
Consulting Geologist
Specializing in Magnetometer Surveys and
Geological Interpretation of Results
 Milam Building San Antonio, Texas

R. H. DANA
Southern Geophysical Company
 Sinclair Building
 FORT WORTH, TEXAS

TEXAS

E. DEGOLYER*Geologist*Esperson Building
Houston, TexasContinental Building
Dallas, Texas**ALEXANDER DEUSSEN***Consulting Geologist*

Specialist, Gulf Coast Salt Domes

1006 Shell Building
HOUSTON, TEXAS**DAVID DONOGHUE***Consulting Geologist**Appraisals - Evidence - Statistics*Fort Worth National Bank Building FORT WORTH,
TEXAS**R. H. FASH***Vice-President*

THE FORT WORTH LABORATORIES

Analyses of Brines, Gas, Minerals, Oil, Interpretation of Water Analyses. Field Gas Testing.

828½ Monroe Street FORT WORTH, TEXAS
Long Distance 138**J. E. (BRICK) ELLIOTT***Petroleum Geologist*

108 West 15th Street

Austin, Texas

JAMES F. GIBBS*Consulting Geologist and
Petroleum Engineer*505 City National Bank Building
WICHITA FALLS, TEXAS**JOHN A. GILLIN***National Geophysical Company*Tower Petroleum Building
Dallas, Texas**CECIL HAGEN***Geologist*

Gulf Bldg.

HOUSTON, TEXAS

MICHEL T. HALBOUTY*Consulting**Geologist and Petroleum Engineer*Suite 729-32, Shell Bldg.
Houston 2, Texas Phone P-6376**SIDON HARRIS***Southern Geophysical Company*

1003 Sinclair Building, FORT WORTH 2, TEXAS

L. B. HERRING*Geologist*

Natural Gas

Petroleum

Second National Bank of Houston, Houston, Texas

JOHN M. HILLS*Consulting Geologist*

Midland, Texas

Box 418

Phone 1015

SAMUEL HOLLIDAY*Consulting Paleontologist*

Houston, Texas

Box 1957, Rt. 17

M. 2-1134

TEXAS

R. V. HOLLINGSWORTH
HAROLD L. WILLIAMS

PALEONTOLOGICAL LABORATORY

Box 51

Phone 2359

MIDLAND, TEXAS

C. E. HYDE

Geologist and Oil Producer

1715 W. T. Waggoner Building

FORT WORTH 2, TEXAS

W. P. JENNY

Consulting Geologist and Geophysicist

Specializing in MICROMAGNETIC SURVEYS,
GEOLOGICAL INTERPRETATIONS and COR-
RELATIONS of seismic, gravimetric, electric and
magnetic surveys.

1404 Esperson Bldg.

HOUSTON, TEXAS

JOHN D. MARR

Geologist and Geophysicist

SEISMIC EXPLORATION, INC.

Gulf Building

Houston, Texas

GEORGE D. MITCHELL, JR.

Geologist and Geophysicist

ADVANCED EXPLORATION COMPANY

622 First Nat'l. Bank Bldg.

Houston 2, Texas

P. E. NARVARTE

Consulting Geophysicist

Seismic Interpretations

Specializing in Faulting and Velocity Analysis

Current Supervision and Review

307 Insurance Building

San Antonio, Texas

DABNEY E. PETTY

10 Tenth Street

SAN ANTONIO, TEXAS

No Commercial Work Undertaken

J. S. HUDNALL

G. W. PIRTLE

HUDNALL & PIRTLE

Petroleum Geologists

Appraisals Reports

Peoples Nat'l. Bank Bldg.

TYLER, TEXAS

JOHN S. IVY

Geologist

1124 Niels Esperson Bldg., HOUSTON, TEXAS

H. KLAUS

Geologist and Geophysicist

KLAUS EXPLORATION COMPANY

Geophysical Surveys and Interpretations

Gravitymeter, Torsion Balance

and Magnetometer

Box 1617, Lubbock, Texas

HAYDON W. McDONNOLD

Geologist and Geophysicist

KEYSTONE EXPLORATION COMPANY

2813 Westheimer Road

Houston, Texas

R. B. MITCHELL

Consulting Geologist

Petroleum and Natural Gas

Second National Bank Building

Houston 2, Texas

Capitol 7319

LEONARD J. NEUMAN

Geology and Geophysics

Contractor and Counselor

Reflection and Refraction Surveys

943 Mellie Esperson Bldg.

Houston, Texas

J. C. POLLARD

Robert H. Ray, Inc.

Rogers-Ray, Inc.

Geophysical Engineering

National Standard Bldg.

Houston 2, Texas

TEXAS

ROBERT H. RAY

ROBERT H. RAY, INC.

*Geophysical Engineering
Gravity Surveys and Interpretations*

Natl. Std. Bldg.

Houston 2, Texas

JAMES L. SAULS, JR.*Geophysicist*ADVANCED EXPLORATION COMPANY
622 First Nat'l. Bank Bldg. Houston 2, Texas**SIDNEY SCHAFER***Consulting Geophysicist*Seismic Reviews Interpretations
Exploration Problems

3775 Harper St.

Houston 5, Texas

A. L. SELIG*Consulting Geologist*

Gulf Building

Houston, Texas

WM. H. SPICE, JR.*Consulting Geologist*2101-02 Alamo National Building
SAN ANTONIO, TEXAS**HARRY C. SPOOR, JR.***Consulting Geologist**Petroleum Natural Gas*

Commerce Building

Houston, Texas

WEST VIRGINIA

DAVID B. REGER*Consulting Geologist*

217 High Street

MORGANTOWN

WEST VIRGINIA

F. F. REYNOLDS*Geophysicist*

SEISMIC EXPLORATIONS, INC.

Natl. Std. Bldg.

Houston 2, Texas

HUGH C. SCHAEFFER*Geologist and Geophysicist*NORTH AMERICAN
GEOPHYSICAL COMPANY

636 Bankers Mortgage Bldg. Houston 2, Texas

Henry F. Schweer

Geo. P. Hardison

SCHWEER AND HARDISON*Independent Consulting
Petroleum Geologists*426-28 Waggoner Building
Wichita Falls, Texas

Specialists: Air-Surface Reconnaissance

E. JOE SHIMEK**HART BROWN**

GEOPHYSICAL ASSOCIATES

Seismic

P.O. Box 6005

Houston 6, Texas

CHARLES C. ZIMMERMAN*Geologist and Geophysicist*

KEYSTONE EXPLORATION COMPANY

2813 Westheimer Road

Houston, Texas

WYOMING

E. W. KRAMPERT*Geologist*

P.O. Box 1106

CASPER, WYOMING

HENRY CARTER REA*Consulting Geologist**Specialist in Photogeology*

Box 294

CASPER, WYOMING

GEOLOGICAL AND GEOPHYSICAL SOCIETIES

COLORADO

ROCKY MOUNTAIN ASSOCIATION OF PETROLEUM GEOLOGISTS

DENVER, COLORADO
President - J. W. Vanderwilt
 Mining Geologist
 Midland Savings Building
1st Vice-President - C. A. Heiland
 Heiland Research Corporation
2nd Vice-President - Robert McMillan
 Geophoto Services, Inc.
 136 East Twentieth Ave.
Secretary-Treasurer - A. W. Cullen
 1024 Continental Oil Building
 Luncheons every Friday noon, Cosmopolitan Hotel.
 Evening dinner (6:15) and program (7:30) first
 Monday each month or by announcement, Cosmo-
 politan Hotel.

ILLINOIS

ILLINOIS GEOLOGICAL SOCIETY

President - Jack Hirsch
 Box 442, Mattoon, Illinois
Vice-President - E. E. Rehn
 Sohio Petroleum Company
 Box 537, Mt. Vernon
Secretary-Treasurer - John B. Patton
 Magnolia Petroleum Company
 Box 535, Mt. Vernon
 Meetings will be announced.

KANSAS

KANSAS GEOLOGICAL SOCIETY

WICHITA, KANSAS
President - Harold O. Smedley
 Skelly Oil Company
Vice-President - Paul A. Harper
 Cities Service Oil Company
Secretary-Treasurer - Francis E. Mettner
 Transwestern Oil Company
 605 Union National Bank Building
 Regular Meetings: 7:30 P.M., Geological Room,
 University of Wichita, first Tuesday of each month.
 The Society sponsors the Kansas Well Log Bureau,
 412 Union National Bank Building, and the Kan-
 sas Well Sample Bureau, 137 North Topeka.

LOUISIANA

THE SHREVEPORT GEOLOGICAL SOCIETY

SHREVEPORT, LOUISIANA
President - T. H. Philpott
 Carter Oil Company
Vice-President - Brame Womack
 Sohio Petroleum Corporation
Secretary-Treasurer - J. Ed. Lytle
 Union Producing Company

Meets monthly, September to May, inclusive, in the
 State Exhibit Building, Fair Grounds. All meetings
 by announcement.

FLORIDA

SOUTHEASTERN GEOLOGICAL SOCIETY

Box 841
 TALLAHASSEE, FLORIDA
President - I. J. Reed
 The California Company
Vice-President - Walter B. Jones
 Geological Survey of Alabama
Secretary-Treasurer - H. A. Sellin
 Magnolia Petroleum Company
 Meetings will be announced. Visiting geologists
 and friends are welcome.

INDIANA-KENTUCKY

INDIANA-KENTUCKY GEOLOGICAL SOCIETY

EVANSVILLE, INDIANA
President - Charles W. Honess
 Gulf Refining Company, Box 774
Vice-President - J. Albert Brown
 Sohio Petroleum Co.
 Owensboro, Kentucky
Secretary-Treasurer - F. H. Latimer
 Sun Oil Company
 Evansville, Ind.
 Meetings will be announced.

LOUISIANA

NEW ORLEANS GEOLOGICAL SOCIETY

NEW ORLEANS, LOUISIANA
President - Gordon I. Atwater
 Consultant, 1034 Whitney Building
Vice-President and Program Chairman - J. L. Patton
 Humble Oil and Refining Company
Secretary-Treasurer - Philip R. Allin
 Gulf Refining Company, Harvey, La.
 Meets the first Monday of every month, October-
 May inclusive, 7:30 P.M., St. Charles Hotel.
 Special meetings by announcement. Visiting geol-
 ogists cordially invited.

LOUISIANA

SOUTH LOUISIANA GEOLOGICAL SOCIETY

LAKE CHARLES, LOUISIANA
President - J. A. Moore
 Union Sulphur Company
Vice-President - James M. Bugbee
 Shell Oil Company, Inc.
Secretary - Lloyd D. Traupe
 Ohio Oil Company
Treasurer - D. E. Newland
 Magnolia Petroleum Company

Meetings: Dinner and business meetings third
 Tuesday of each month at 7:00 P.M. at the Majestic
 Hotel. Special meetings by announcement. Visiting
 geologists are welcome.

MICHIGAN

MICHIGAN
GEOLOGICAL SOCIETY

President Rex P. Grant
Michigan Geological Survey
Capitol Savings and Loan Bldg., Lansing
Vice-President Richard H. Wolcott
Sohio Petroleum Company, Mt. Pleasant
Secretary-Treasurer Charles K. Clark
Pure Oil Company
402 2d Natl. Bank Bldg., Saginaw
Business Manager Kenneth A. Gravelle
Gulf Refining Company, Box 811, Saginaw

Meetings: Bi-monthly from November to April at Lansing. Afternoon session at 3:00, informal dinner at 6:30 followed by discussions. (Dual meetings for the duration.) Visiting geologists are welcome.

MISSISSIPPI

MISSISSIPPI
GEOLOGICAL SOCIETY
JACKSON, MISSISSIPPI

President Frederic F. Mellen
Mellen & Monsour
Box 2571, W. Jackson Sta.
Vice-President J. B. Wheeler
Stanolind Oil and Gas Company
Secretary-Treasurer H. L. Spyres
Skelly Oil Company

Meetings: First and third Thursdays of each month, from October to May, inclusive, at 7:30 P.M., Edwards Hotel, Jackson, Mississippi. Visiting geologists welcome to all meetings.

OKLAHOMA

ARDMORE
GEOLOGICAL SOCIETY
ARDMORE, OKLAHOMA

President F. P. Schweers
The Texas Company, Box 539
Vice-President Paul L. Bartram
Phillips Petroleum Company
Secretary-Treasurer Ben S. Curtis
Independent, Box 156

Dinner meetings will be held at 7:00 P.M. on the first Wednesday of every month from October to May, inclusive, at the Ardmore Hotel.

OKLAHOMA CITY
GEOLOGICAL SOCIETY
OKLAHOMA CITY, OKLAHOMA

President Gerald C. Maddox
Carter Oil Company
Vice-President Harold J. Kleen
Skelly Oil Company
Secretary-Treasurer Frederick H. Kate
Shell Oil Company, Inc.
965 First National Building

Meetings: Technical program each month, subject to call by Program Committee, Oklahoma City University, 24th Street and Blackwelder. Luncheons: Every second and fourth Thursday of each month, at 12:00 noon. Y.W.C.A.

SHAWNEE
GEOLOGICAL SOCIETY
SHAWNEE, OKLAHOMA

President Delbert F. Smith
Oklahoma Seismograph Company
Vice-President Henry A. Campo
Atlantic Refining Company
Secretary-Treasurer Marcelle Mousley
Atlantic Refining Company, Box 169

Meets the fourth Thursday of each month at 8:00 P.M., at the Aldridge Hotel. Visiting geologists welcome.

TULSA GEOLOGICAL SOCIETY
TULSA, OKLAHOMA

President John G. Bartram
Box 591, Stanolind Oil and Gas Co.
1st Vice-President Russell S. Tarr
Independent, Beacon Building
2nd Vice-President John C. Maher
U. S. Geological Survey
Secretary-Treasurer John R. Crain
Ashland Oil and Refining Company
Editor Robert F. Walters
Box 661, Gulf Oil Corporation

Meetings: First and third Mondays, each month, from October to May, inclusive at 8:00 P.M., University of Tulsa, Kendall Hall Auditorium. Luncheons: Every Friday (October-May), Chamber of Commerce Building.

TEXAS

CORPUS CHRISTI GEOLOGICAL
SOCIETY
CORPUS CHRISTI, TEXAS

President W. E. Greenman
The Texas Company, 902 Jones Building
Vice-President Dale L. Benson
Sinclair Prairie Oil Company, Box 480
Secretary-Treasurer O. G. McClain
Consultant, 224 Nixon Building

Regular luncheons, every Wednesday, Petroleum Room, Plaza Hotel. 12:05 P.M. Special night meetings, by announcement.

DALLAS
GEOLOGICAL SOCIETY
DALLAS, TEXAS

President John W. Clark
Magnolia Petroleum Company, Box 900
Vice-President Willis G. Meyer
DeGolyer and MacNaughton, Continental Building
Secretary-Treasurer John M. Clayton
Seaboard Oil Company, 1400 Continental Building
Executive Committee Fred H. Wilcox
Magnolia Petroleum Company

Meetings: Monthly luncheons by announcement. Special night meetings by announcement.

TEXAS

EAST TEXAS GEOLOGICAL
SOCIETY
TYLER, TEXAS

President T. H. Shelby, Jr.
Humble Oil and Refining Company
Vice-President George N. Ely
Continental Oil Company
907 Peoples Bank Building
Secretary-Treasurer B. F. Murphy
Amerala Petroleum Corporation
Box 2026

Luncheons: Each week, Monday noon, Blackstone Hotel.
Evening meetings and programs will be announced. Visiting geologists and friends are welcome.

HOUSTON
GEOLOGICAL SOCIETY
HOUSTON, TEXAS

President Shapleigh G. Gray
Consultant, 1713 Esperson Building
Vice-President Charles H. Sample
J. M. Huber Corporation
721 Bankers Mortgage Bldg.
Secretary A. F. Childers
Gulf Oil Corporation, Box 2100
Treasurer Wayne Z. Burkhead
Union Oil Company of California
1134 Commercial Bldg.

Regular meeting held the second and fourth Mondays at noon (12 o'clock), Mezzanine floor, Rice Hotel. For any particulars pertaining to the meetings write or call the secretary.

SOUTH TEXAS GEOLOGICAL
SOCIETY
SAN ANTONIO, TEXAS

President Thornton Davis
Peerless Oil and Gas Company
2023 Alamo National Building
Vice-President Marion J. Moore
Transwestern Oil Company, 1600 Milam Building
Secretary-Treasurer Paul B. Hinyard
Shell Oil Company, Inc.
2000 Alamo National Building

Meetings: One regular meeting each month in San Antonio. Luncheon every Monday noon at Milam Cafeteria, San Antonio.

WEST VIRGINIA

THE APPALACHIAN GEOLOGICAL
SOCIETY
CHARLESTON, WEST VIRGINIA
P. O. Box 2603

President Velcair C. Smith
1901 Kanawha Valley Building
Vice-President W. B. Maxwell
United Fuel Gas Company, Box 1273
Secretary-Treasurer R. L. Alkire
605 Union Building
Editor J. D. Castner
Box 1433

Meetings: Second Monday, each month, except June, July, and August, at 6:30 P.M., Kanawha Hotel.

FORT WORTH
GEOLOGICAL SOCIETY
FORT WORTH, TEXAS

President John H. Wilson
Independent Exploration Company
2210 Ft. Worth National Bank Bldg.
Vice-President Edwin M. Rowser
The Texas Company, Box 1720
Secretary-Treasurer S. K. Van Steenberg
Sinclair Prairie Oil Company
901 Fair Building

Meetings: Luncheon at noon, Hotel Texas, first and third Mondays of each month. Visiting geologists and friends are invited and welcome at all meetings.

NORTH TEXAS
GEOLOGICAL SOCIETY
WICHITA FALLS, TEXAS

President Dolph S. Simic
Bay Petroleum Corporation
Vice-President Lynn L. Harden
Sinclair Prairie Oil Company
Secretary-Treasurer D. T. Richards
George W. Graham

Meetings: Each week, Tuesday, 12:30 P.M., Texas Electric Auditorium; Each month, first Thursday evening. Special night meetings announced. All geologists always welcome.

WEST TEXAS GEOLOGICAL
SOCIETY
MIDLAND, TEXAS

President B. A. Ray
Consulting, Box 1383
Vice-President W. J. Hilsweck
Gulf Oil Corporation, Box 1150
Secretary-Treasurer Charles A. Shaw
Forest Oil Corporation, Box 366

Meetings will be announced.

WYOMING

WYOMING GEOLOGICAL
ASSOCIATION
CASPER, WYOMING
P. O. Box 343

President Charles T. Jones
Stanolind Oil and Gas Company
1st Vice-President Rolland W. McCanne
Ohio Oil Company
2nd Vice-President (Programs) Thomas C. Hiestand
Cities Service Oil Company
Secretary-Treasurer William A. Thompson
The Texas Company
Informal luncheon meetings every Friday, 12 noon, Townsend Hotel. Visiting geologists welcome.
Special Meetings by announcement.

**THE SOCIETY OF
EXPLORATION GEOPHYSICISTS**

President J. J. Jakosky
University of Southern California, Los Angeles
Vice-President Cecil H. Green
Geophysical Service, Inc., 1311 Republic Bank
Building, Dallas, Texas
Editor L. L. Nettleton
Gravity Meter Exploration Co.
1348 Esperson Bldg., Houston, Tex.
Secretary-Treasurer George E. Wagoner
Carter Oil Company, Shreveport, Louisiana
Past-President Henry C. Cortes
Magnolia Petroleum Co., Dallas, Texas
Business Manager Colin C. Campbell
213 Ritz Building, Tulsa, Oklahoma
P.O. Box 1614

Source Data

**DIRECTORY OF GEOLOGICAL MATERIAL
IN NORTH AMERICA**

By

J. V. HOWELL AND A. I. LEVORSEN
Tulsa, Oklahoma, and Stanford University, California

- I. General Material:—National and continental in area
 - A. Publications and non-commercial publishing agencies, regional, national, and continental
 - B. Bibliographies, general
 - C. Dictionaries, glossaries, encyclopedias, statistics, handbooks
 - D. Miscellaneous books and publications of general geological
 - E. Commercial map publishers
 - F. Regional and national geologic and physiographic maps
 - G. State and Province geological maps
 - H. Trade journals: oil, gas, mineral industry
 - I. Libraries furnishing photostat and microfilm service
 - J. Thin-section and rock-polishing service
- II. Specific material:—State and Province in area
 - A. Canada, by provinces and Newfoundland
 - B. Central American countries
 - C. Mexico
 - D. United States—states and territories

Originally published as Part II of the August, 1946, Bulletin.

PRICE, 75¢ POSTPAID

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
BOX 979, TULSA 1, OKLAHOMA, U.S.A.

DIRECTORY OF GEOLOGICAL MATERIAL IN NORTH AMERICA

J. V. HOWELL AND A. I. LEVORSEN
Tulsa, Oklahoma, and Stanford University, California

List of names and addresses of sources of information needed by the geologist: maps, well data, aerial photographs, geologic publications, books, reports, descriptions, special services, basic data.

Originally published as Part II of the August, 1946, *Bulletin*.
Separate copies in paper covers. 112 pages. Price, 75¢.

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
BOX 979, TULSA 1, OKLAHOMA, U.S.A.

The Annotated Bibliography of Economic Geology Vol. XV

Orders are now being taken for the entire volume at \$5.00 or for individual numbers at \$3.00 each. Volumes I-XIV can still be obtained at \$5.00 each.

The number of entries in Vol. XV, No. 1, is 1,079. No. 2 is being printed.

Of these, 266 refer to *petroleum, gas, etc., and geophysics*. They cover the world, so far as information is available in war time.

If you wish future numbers sent you promptly, kindly give us a *continuing order*.

An Index of the 10 volumes was issued in May, 1939. Price: \$5.00

Economic Geology Publishing Co.
Urbana, Illinois, U.S.A.

JOURNAL OF PALEONTOLOGY

Six numbers constitute the volume for 1946. The only American journal devoted to this field. Subscription: \$6.00 per year.

JOURNAL OF SEDIMENTARY PETROLOGY

Three numbers constitute the volume for 1946. Subscription: \$3.00. These publications of the Society of Economic Paleontologists and Mineralogists should be in the library of all working geologists. Write S.E.P.M., Box 979, Tulsa 1, Oklahoma.



AERIAL PHOTOGRAPHY
RECONNAISSANCE MOSAICS
PRECISE AERIAL MOSAICS
TOPOGRAPHIC SURVEYS

For information write Department H

AERO SERVICE CORPORATION

Since 1919

PHOTOGRAMMETRIC ENGINEERS
236 E. Courtland Street, Philadelphia 20, Penna.



REDUCING EXPLORATION COSTSIN TERMS OF OIL DISCOVERED

During the past 19 years we have been privileged to conduct Barret Magnetic Surveys for 73 clients, representing a good cross section of the exploration branch of the petroleum industry.

It is a significant fact that most of our work in recent years has been done for some of our earliest clients.

These clients and others continue to use our services for the sole reason that it has proved profitable to them in their search for new oil reserves.

We will be pleased to explain without obligation how you may use Barret Magnetic Surveys to cut your exploration costs in terms of barrels of oil discovered.

WILLIAM M. BARRET, INC.
Consulting Geophysicists
GIDDENS-LANE BLDG. SHREVEPORT, LA.

UNITED

GEOPHYSICAL COMPANY

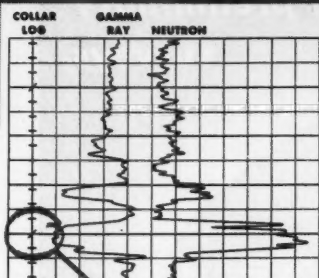
505 E. COLORADO ST., PASADENA 1, CALIF.

OTHER OFFICES

TULSA • HOUSTON • NEW YORK

CARACAS • BARRANQUILLA • SANTIAGO

Right Combination



2 SIMPLE STEPS ASSURE ACCURATE PERFORATION PLACEMENT

The location of each collar is recorded electrically with Radioactivity Logging equipment, and each collar is shown on the Log in its fixed relation to the formation curves. The Collar Log is not changed for when run with a Radioactivity Well Log, but is furnished as an additional feature to provide Oil Well Operators with more useful information about their wells.

The reference collar nearest the shooting zone is picked up by the Collar Locator on the Gun Perforator. This combination permits accurate gun perforating at even the thinnest zones without dependence upon such questionable procedures as bottom checks or artificially placed formation markers.

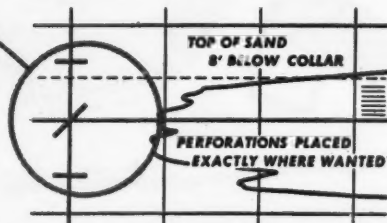
For more details about these Lane-Wells Services consult your Composite Catalog—pages 1980-1993, or call your nearest Lane-Wells Branch.

"Call Lane-Wells and have the job done right"

Gun Perforating

LANE-WELLS SYSTEM OF COLLAR LOCATION ELIMINATES MEASUREMENT VARIABLES

Lane-Wells Collar Log establishes the relationship between formations and collars. Each collar becomes an accurate bench mark for all subsequent well operations. Use of these bench marks means a saving of time and trouble for you in testing, plugback operations, squeeze cementing, acidising, and other completion practices utilizing gun perforating.



Tomorrow's Tools—Today!



LOS ANGELES • HOUSTON • OKLAHOMA CITY
24-HOUR SERVICE General Offices, Export Offices and Plant 39 BRANCHES
5610 S. SOTO ST., LOS ANGELES 11, CALIFORNIA

Altimeters

for all preliminary
surveys



How much money will this instrument save YOU?
Preliminary surveys in 1/10th the time with accuracy
better than 1 part in 1000.

Type SA-1: Range 4,500' (750' to 3,500') in intervals of 25'

Type SA-2: Range 10,500' (1,500' to 7,000') in intervals of 25'

Type SA-3: Range 15,000' (300' to 14,500') in intervals of 10'

All models priced \$200 complete with case, hand & shoulder
straps, magnifier and thermometer. **IMMEDIATE DELIVERY**
—see your dealer or write direct for descriptive folder.

AMERICAN PAULIN SYSTEM

Manufacturers of Precision Instruments

3647 SOUTH FLOWER STREET, LOS ANGELES 15, CALIFORNIA

Altimeters

KEYSTONE

SEISMIC SURVEYS



KEYSTONE EXPLORATION COMPANY

OFFICES AND LABORATORY

2813 WESTHEIMER ROAD

HOUSTON • TEXAS



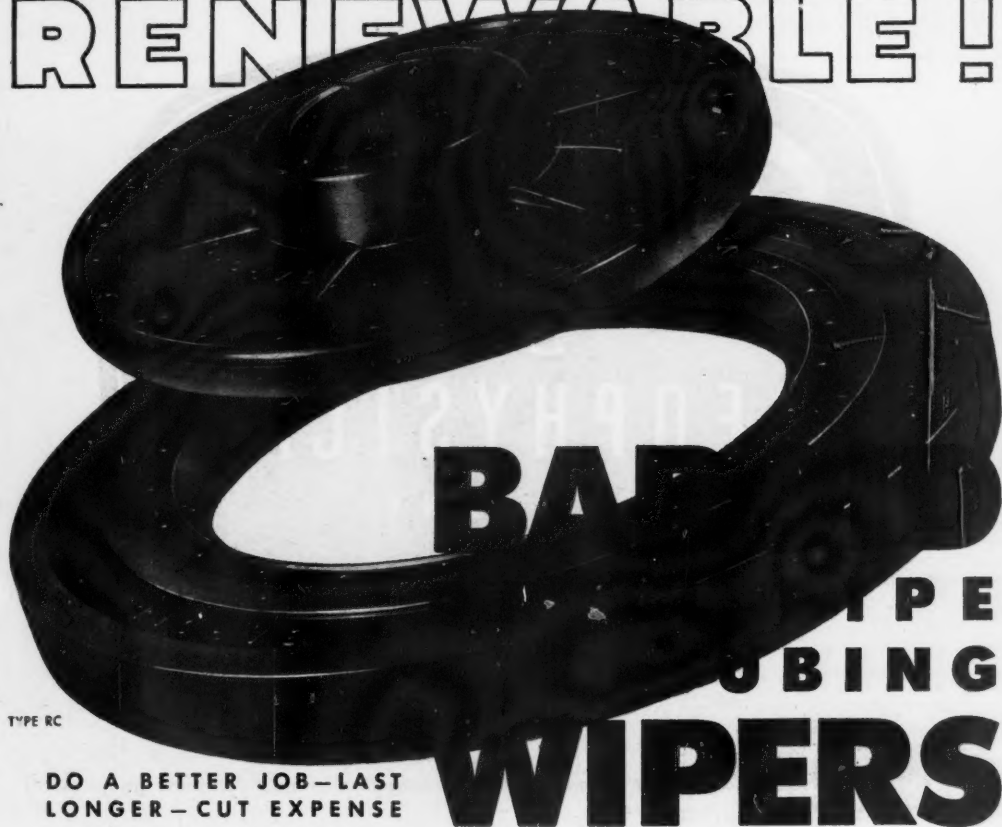
General
G E C
GEOPHYSICAL COMPANY HOUSTON

ACCURATE
GEOPHYSICAL
SURVEYS

•
CORE DRILLING



RENEWABLE!



TYPE RC

DO A BETTER JOB—LAST LONGER—CUT EXPENSE

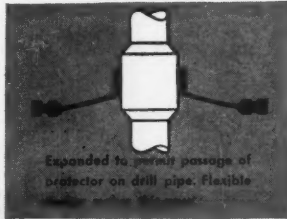
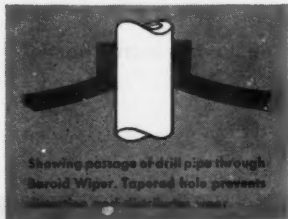
Replaceable-Insert (RC) and One-Piece (S) Types. Replaceable Inserts (Type RC only) make the wiper good for many thousands of feet more pipe at a fraction of the cost of a new wiper. One rim will outlast several inserts.

Tapered Center Hole assures greater wiping efficiency and longer life. Raised Center Hub gives greater wiping surface. Strong, Flexible Construction and

uniformly blended rubber provide great elasticity and long wear.

Baroid Wipers are products of our Specialties Department which is devoted entirely to designing and producing new and better tools for the oil industry. Baroid Wipers are sold exclusively through Supply Houses. Write for literature and prices.

TYPE S



BAROID SALES DIVISION

NATIONAL LEAD COMPANY

BAROID SALES OFFICES: LOS ANGELES 12 • TULSA 3 • HOUSTON 2

Western

GEOPHYSICAL

COMPANY

Consisting in the rigidly maintained largest and most complete geophysical research facilities in the world together with unexcelled equipment, experienced field crews and proven interpretation technique, Western Geophysical Company meets every requirement of operators desiring a complete and well-rounded geophysical service.

Western's seismic and gravity crews are now operating in all parts of the United States and in South America. Western service is available for surveys in any part of the world. Inquiries are invited.

Western GEOPHYSICAL COMPANY

HENRY SALVATORE, PRESIDENT

EDISON BLDG., LOS ANGELES 15, CALIF. • FIRST NATIONAL BANK BLDG., DALLAS 2, TEXAS
118 COMMERCE ST., NATCHEZ, MISSISSIPPI

Important for Paleontologists and Stratigraphers!

MIOCENE STRATIGRAPHY OF CALIFORNIA

By ROBERT M. KLEINPELL

This Work Establishes a Standard Chronologic-Biostratigraphic Section
for the Miocene of California and Compares It with the Typical
Stratigraphic Sequence of the Tertiary of Europe

WHAT OTHERS HAVE WRITTEN ABOUT IT

"In spite of any defects it may have, moreover, many of us suspect that Kleinpell's book is of the kind called epoch-making. If so, in 50 or 100 years it will stand out like a beacon among its contemporaries and, along with a very few others of them will read with a 'modern' tang. Oppel's 'Die Juraformation,' or Sues' 'Die Entstehung der Alpen,' or to go back to the beginning, De Saussure's 'Les Voyages dans les Alpes' may be cited among older geological classics that are now distinguished by this same tang."—Ralph D. Reed in *Journal of Paleontology*, Vol. 13, No. 6 (November, 1939), p. 625.

"The Neogene of California is disposed in tectonic basins, about a dozen in number, from Humboldt in the north to Los Angeles in the south. About half-way along is the Paso Robles basin, and in this lies the Reliz Canyon, which provides the author with his type section. The aerial photograph serving as frontispiece shows the area to be sufficiently arid to give a practically continuous exposure; but one must admire the painstaking determination with which so many successive associations of Foraminifera were collected, identified and tabulated. Such labour would scarcely have been thought of without the stimulus which the search for oil has given to the detailed study of Foraminifera.


"This should be the standard work on the Miocene of California for years to come."
A.M.D. in *Nature*, Vol. 144 (London, December 23, 1939), p. 1030.

-
- 450 pages.
 - 14 line drawings, including correlation chart in pocket.
 - 22 full-tone plates of Foraminifera.
 - 18 tables (check lists and range chart of 15 pages).
 - Bound in blue cloth; gold stamped; paper jacket; 6x9 inches.

PRICE: \$5.00, POSTPAID

(\$4.50 TO A.A.P.G. MEMBERS AND ASSOCIATE MEMBERS)

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
BOX 979, TULSA 1, OKLAHOMA, U.S.A.



GEOPHYSICAL
ENGINEERING
GRAVITY SURVEYS
CONSULTING
CONTRACTING

Foreign

Domestic

ROGERS-RAY, INC

Domestic

NATIONAL STANDARD BLDG.
HOUSTON 2, TEXAS

EXPLORACIÓN

RO-RAY-CO

SÍSMICA

EDIFICIO STANDARD
CARRANZA, VERMONTA





The yardstick for measuring the value of any seismograph service is accuracy of interpretation . . . a qualification that comes only with long and diversified experience.

SEISMIC EXPLORATIONS, INC.

Houston, Texas

Seismograph Equipment

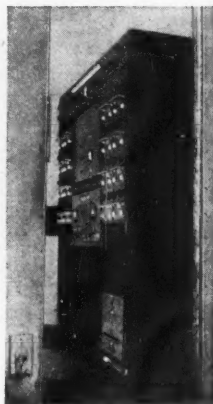
Manufactured by

NORTH AMERICAN

This equipment as well as the Portable Gravity Meter, other geophysical apparatus and precision equipment is manufactured in our own Laboratories.

REFLECTION SEISMOGRAPH UNITS

This complete 16 channel, dual recording unit is mounted in a special stainless steel body, having two power driven cable reels, completely wired, tested and ready for field service. Amplifiers have full, automatic amplitude control and complete rejection of 60 cycle power line interference. It has inverse feed back filters, 6 filter settings controlled by selector switch on instrument panel, which makes it possible to obtain any 6 filter curves. Interchangeable plug-in type filter units make it possible to readily change complete system of filter curves. Dual output is available, providing for mixed and unmixed recording simultaneously. Light weight seismometers are furnished with either fluid or electro-magnetic damping.



PORTABLE CABLE REEL

This light-weight reel, designed for use in areas inaccessible by truck, carries 1200 feet of cable and is worn on the back or chest. When laying cable it is worn on the back, the cable unreeling as the operator walks along. When reeling in, it is worn on the chest, and the cable wound on the drum by the crank as the operator walks along. Wide web belting assures comfortable fit. The complete reel weighs only 5 pounds. Weight with 1200 feet of tapered seismograph cable is only 23 pounds. The reel is available with or without cable.

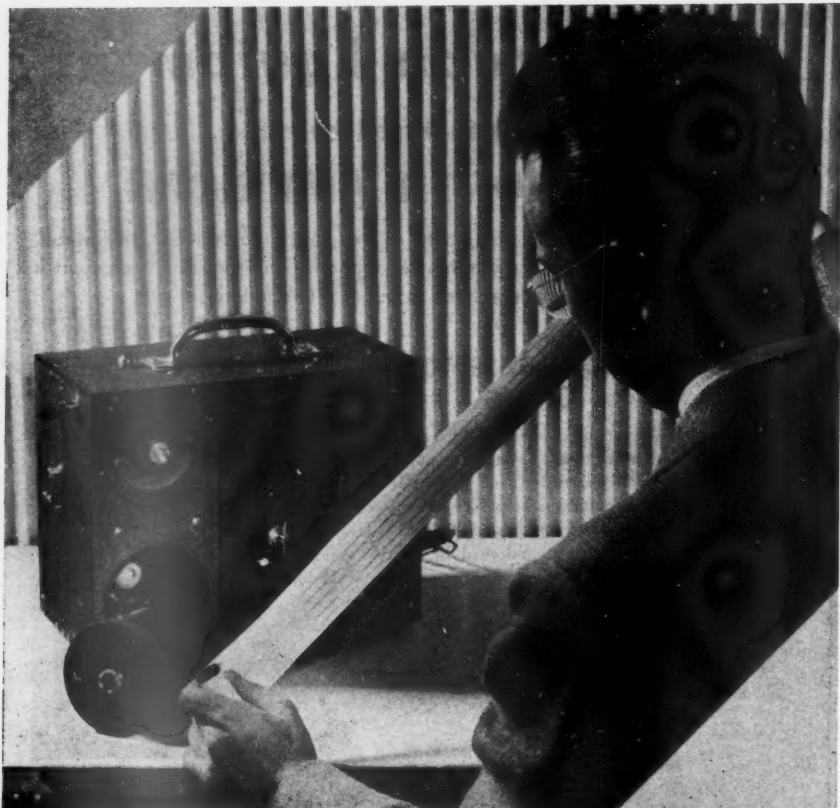
NORTH AMERICAN GEOPHYSICAL COMPANY

Gravity-Magnetic-Seismic Surveys

Geophysical Apparatus

636 Bankers Mortgage Building

Houston 2, Texas



OSCILLOGRAPH RECORDS TELL THE STORY...

The accuracy of seismic surveys depends, in a large measure, upon the design and precision of your oscillographs... To build seismic instruments that are accurate and dependable, requires extensive engineering and production facilities... Because the Heiland organization has these facilities, Heiland oscillographs have earned the confidence of oil exploration men throughout the world... Write for complete information on all types of seismic recorders.



HEILAND

Research
Corporation
DENVER

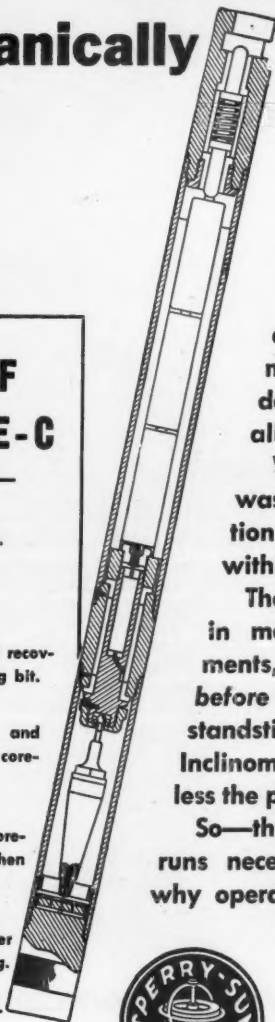
E-C Inclinometer

versus

Mechanically operated instruments

6 WAYS OF USING THE E-C

- 1.** On Measuring Line.
- 2.** On Sand Line.
- 3.** As a Go-Devil and recovered when changing bit.
- 4.** As a Go-Devil and picked up with a core-barrel overshot.
- 5.** Run in with a core-barrel overshot when picking up a core.
- 6.** Run inside of bailer in cable tool drilling.



Many cases have been brought to our attention where records made by mechanically operated instruments showed much greater deviation than that which actually existed.

When the E-C Inclinometer was brought on the job the deviation was actually found to be within the 2° limit.

The answer lies in the fact that in mechanically operated instruments, it is possible to make a record before the plumb bob comes to a standstill. In the case of the E-C Inclinometer, no record is possible unless the plumb bob is at rest.

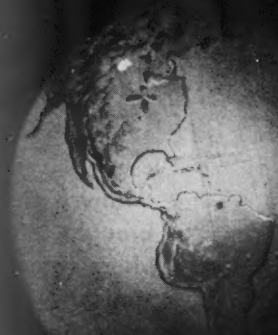
So—there's no uncertainty—no new runs necessary—no time lost. That's why operators everywhere are turning to the E-C.



SPERRY-SUN WELL SURVEYING CO.

Offices: Philadelphia, Pa.; Houston, Corpus Christi, Falfurrias, Marshall, Odessa, Texas; Lafayette, La.; Long Beach, Bakersfield, Calif.; Oklahoma City, Okla.; Casper, Wyo.

VOUEGARIE



As the establishment of world-wide oil reserves moves into greater prominence, our twenty-one years of geophysical surveying experience and accurate interpretation of authentic subsurface data, becomes increasingly valuable in mapping the course of future oil development.

PETTY GEOPHYSICAL ENGINEERING CO.

SAN ANTONIO, TEXAS

SEISMIC • GRAVITY • MAGNETIC SURVEYS

SOUTHERN

PRECISION SEISMIC SURVEYS

REFLECTION

REFRACTION

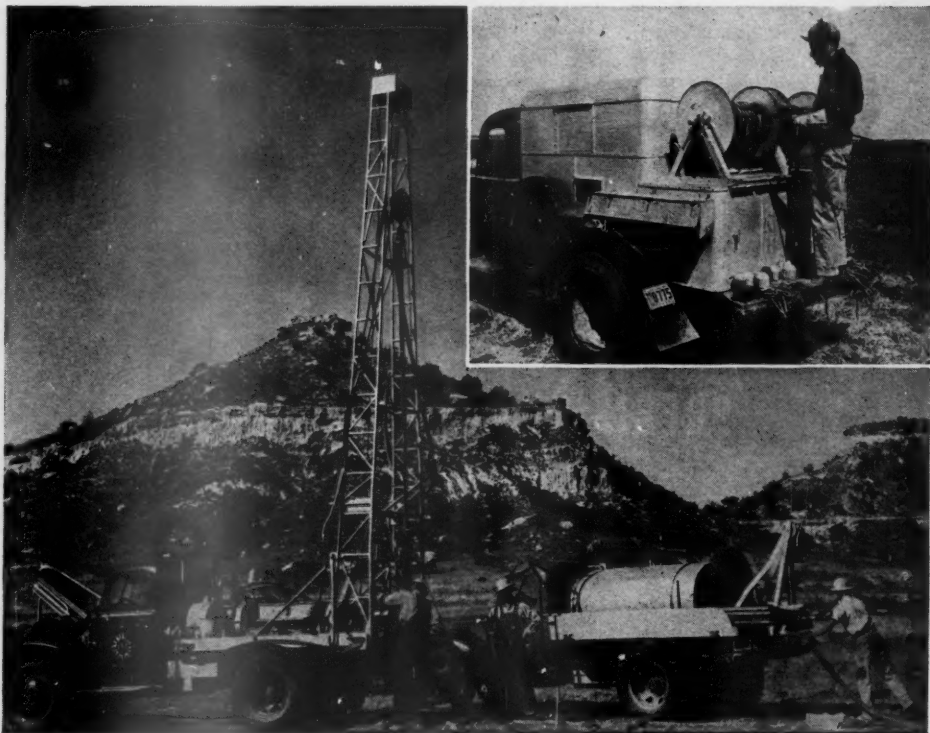
DATA REANALYSIS

SOUTHERN GEOPHYSICAL COMPANY

SINCLAIR BUILDING

SIDON HARRIS, PRESIDENT

FORT WORTH, TEXAS



**Where seismograph work involves special problem shooting
... Independent's 14 years of experience provides the
"know how" that gets the job done.**

Since 1932 Independent has had from two to seventeen crews in the field at all times...operating from the swamps of Louisiana to the rugged foothills of Montana, in coastal tide waters and in the jungle of South America.

The benefit of this wide variety of experience in 26 states and foreign fields is available to all Independent clients. You are invited to consult with us about your exploration problem.

Independent
EXPLORATION COMPANY

**SEISMOGRAPH
GRAVIMETER
MAGNETOMETER
ESTABLISHED IN 1932**

ESPERSON BUILDING

HOUSTON, TEXAS

GMX

DEPENDABLE GRAVITY
SURVEYS

FOR MORE than twenty years we have
been making and interpreting gravity sur-
veys in most of the petroleum provinces
of the world . . . localizing structural areas.

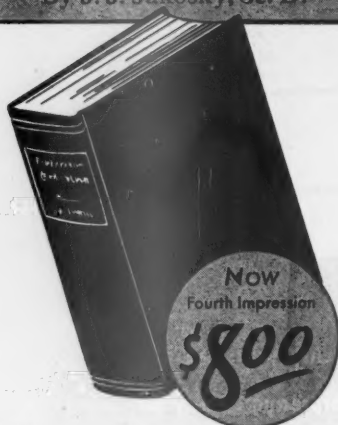
W. G. SAVILLE . . . A. C. PAGAN . . . L. L. NETTLETON

GRAVITY METER
EXPLORATION CO.
geophysicists

Esperon Building, Houston, Texas

Exploration Geophysics

By J. J. Jakosky, Sr. D.



Original and important geophysical information for mining and petroleum engineers, supervisors and production men of mining and oil companies, geologists, geophysicists, prospectors, patent attorneys and others. Dr. Jakosky, a nationally known authority in Engineering Education and Geophysical Research, was aided by staff of 32 nationally known geophysicists in compiling this book.

A Complete Compilation of Modern Geophysical Techniques

Describes and illustrates the fundamental theories, detailed descriptions of instruments, equipment and field techniques of the recognized exploratory geophysical methods and applications to problems of economic geology. 430 illustrations; 786 pages, easy to read. Already adopted as textbook by many leading universities. A standard reference book of all times. Sold with privilege of return for full credit.

ORDER YOUR COPY NOW

EXPLORATION GEOPHYSICS

1063 Gayley Ave., Los Angeles 24, Calif.

LUFKIN

CHROME CLAD STEEL TAPES



"ATLAS"
King of all
Gaging Tapes

The outstanding
development in
the manufacture
of measuring
tapes

Features of all Chrome Clad Tapes:

- Easy to read markings that are durable
- Line resists rust, will not crack, chip or peel
- Line is extra strong.

Send for Catalog No. 12 showing complete line of Tapes, Rules and Precision Tools

THE LUFKIN RULE CO.

Saginaw, Michigan

New York City

GEOPHYSICS

Offers the following
subscription rates:

	U.S.	Foreign
One year, 4 issues	6.00	6.50
Single copies	2.00	2.20

Special discounts to public libraries
and government agencies

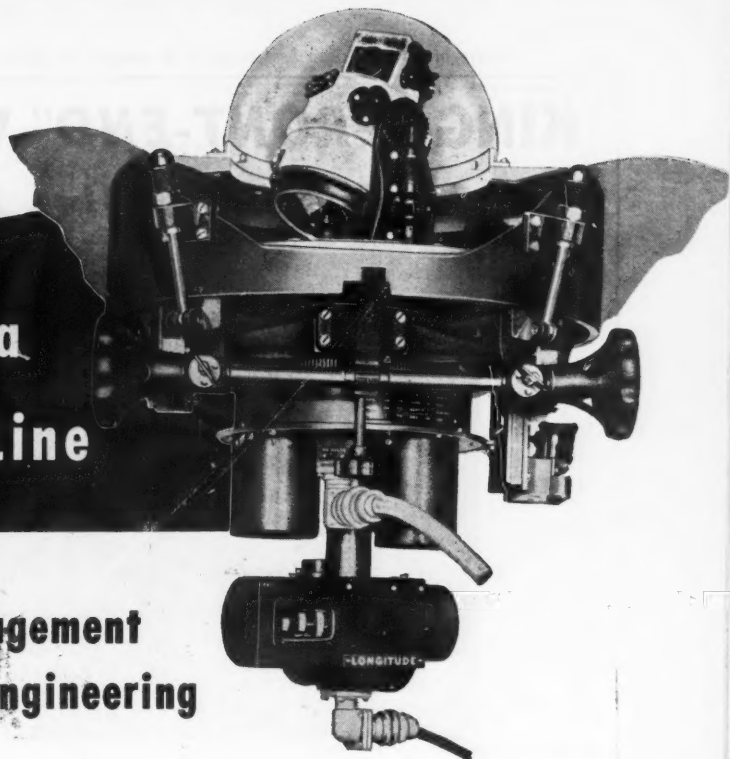
Address subscriptions to

**SOCIETY OF EXPLORATION
GEOPHYSICISTS**

P.O. Box 1614
Tulsa, Oklahoma

Thinking a Straight Line

for better management
and engineering



THE FAIRCHILD SOLAR NAVIGATOR is an important link in the Fairchild Aerial Survey. It is a "thinking" instrument that keeps the photo plane on a *straight* course when the terrain offers no clearly defined sighting points (as on many expeditionary surveys) . . . or when pilot visibility is poor and photographic visibility is good (this is not the paradox it may seem to be). The term "thinking" is applied because the Fairchild Solar Navigator automatically applies corrections that an expert pilot would make under perfect aerial mapping conditions; e.g., it corrects for variables like wind change and compass errors.

THAT FAIRCHILD conceived the Solar Naviga-

tor is as it should be. For this organization has consistently led the way in the development of the tools and techniques that spell the difference between simple aerial photography and the complex science of aerial photogrammetry. Use Fairchild consultation service when planning a survey.

For Industry, Commerce and Public Works

Since 1920, Fairchild has served clients the world over . . . conducting domestic and expeditionary surveys in the fields of:

Petroleum
Mining
Geology
Forestry
Waterways

Highways
Railroads
Traffic
Utilities
Pipe Lines

Taxation
Harbors
Flood Control
City Planning
Legal Evidence

Fairchild **AERIAL SURVEYS, INC.**
Photogrammetric Engineers

224 EAST ELEVENTH STREET, LOS ANGELES 15, CALIFORNIA • 21-21 FORTY-FIRST AVENUE, LONG ISLAND CITY 1, N.Y.

KING "FRONT-END" WINCH

for Civilian Willys Jeep



The Model 100 King Winch for Civilian Willys Jeep incorporates the same dependable features that have been used for years on passenger cars and half ton pick-ups in the oil fields all over the world. These rugged and dependable features together with the latest improvements, such as centralized lubrication and improved drive-shaft suspension, assure a "front-end" winch that will give trouble-free service and long life.

Power for the winch is taken from the front end of the engine crankshaft by means of a solid sheave and a patented sliding clutch using rubber contact blocks to absorb shock and misalignment. This clutch assures a positive drive, eliminates slippage, and can be engaged or disengaged at any time (even under load and with engine idling).

The winch sets directly in the center on front of the Jeep and is easily and safely operated by one man. Recommended cable 150' 5/16" 6 x 19 hemp center wire rope.

Weight of complete installation 126 lbs. Speed ratio cable drum to engine 72 to 1.

Sold Exclusively Through Willys Distributors and Dealers

KOENIG IRON WORKS
2214 Washington Ave. HOUSTON 10, TEXAS

C. H. FROST GRAVIMETRIC SURVEYS, INC.

C. H. FROST, *President*

JOSEPH A. SHARPE, *Vice-President*

GRAVIMETERS manufactured under license from Standard Oil
Development Company

GRAVIMETRIC AND MAGNETIC SURVEYS carefully con-
ducted by competent personnel

GEOLOGIC INTERPRETATION of the results of gravimetric
and magnetic surveys

1242 South Boston Avenue

Tulsa 3, Oklahoma

Publishers: G. E. STECHERT & CO., New York · DAVID NUTT, London · PRESSES UNIVERSITAIRES DE FRANCE, Paris · NICOLA ZANICHELLI, Bologna · AGIOTAGIO, Palma de Mallorca · F. MACHADO & Cia., Porto · BUCHHANDLUNG d. KÖN. UNG. UNIVERSITÄTSDRUCKEREI, Budapest · F. ROUGE & Cie., Lausanne.

1946 40th Year
"SCIENTIA"

REVIEW OF SCIENTIFIC SYNTHESIS
Published every month (each number containing 100 to 120 pages)
Chief Editor: Paolo Bonetti

SCIENTIA has a really world-wide circulation.

SCIENTIA is a synthesis and unification of science, that deals in its articles with the newest and most fundamental problems of all branches of knowledge: scientific philosophy, history of science, mathematics, astronomy, geology, physics, chemistry, biological sciences, physiology, psychology, history of religions, anthropology, linguistics.

SCIENTIA publishes articles in the language of their authors. Every number has a **Supplement** containing the complete French translation of the articles, which in the text are published in English, Italian, German, or Spanish. (*Write for a free copy to "Scientia", Asso (Como, Italy) sending 150 Ital. Lire in stamps of your country.*)

SUBSCRIPTION: \$12.00; sh. 60.00; Ital. Lire 1200.—
For information apply to "SCIENTIA" Asso (Como, Italy)

GEOPHYSICAL SURVEYS UNIVERSAL EXPLORATION COMPANY

2044 Richmond Road
HOUSTON 6, TEXAS

Paul Charin, Pres. — John Gilmore, V.P. — C. C. Hinson, V.P.

New Third Edition . . .**-- a complete, systematic treatment of
the technology of oil field development**

- fundamentals
- problems
- methods
- equipment

The new edition of this complete reference book on the fundamentals, problems, methods and equipment used in petroleum production, supplies a broad, practical understanding of the field, and a modern guide to the best practices in all steps of oil field development, from exploration to the finishing of the wells. The book presents a comprehensive review of all the literature of oil-field development technology, to meet the needs and problems of engineers and petroleum executives alike.

Just published!

Petroleum Production Engineering

OIL FIELD DEVELOPMENT

By **LESTER CHARLES UREN**

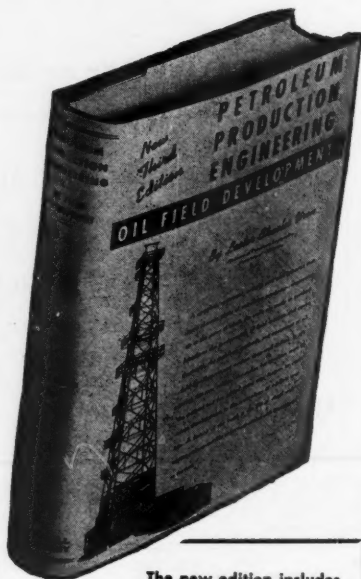
Professor of Petroleum Engineering, University of California

750 pages, 5 3/4 x 8 3/4, 383 illustrations, \$7.00

This book provides a basic reference work on the technology of oil-field development, and a thorough, practical treatment of all steps up to the point at which the wells are ready to produce.

The book covers in careful and practical detail the range of processes from petroleum exploration methods, through principles of development, drilling equipment and methods, procedures in casing wells, water exclusion, well testing and completion, logging techniques and methods of assembling records of subsurface data. It constitutes the most detailed and comprehensive treatise on these topics available.

Formulae, tables and graphic data helpful in the solution of many engineering problems incidental to oil-field development operations are presented. Selected bibliographies and footnotes afford references leading to the best sources of information on any topic to be studied in greater detail.



The new edition includes
such developments as:

- Drilling wells to greater depths than ever before, and at lower unit cost
- New and more efficient types of drilling equipment
- New methods of installing and cementing casing in wells
- New techniques of logging, testing and completing wells
- Extended knowledge of conditions surrounding the occurrence of petroleum in nature
- Broadened application of engineering to oil field development

Order from

The American Association of Petroleum Geologists

Box 979, Tulsa 1, Oklahoma, U.S.A.

ADVANCED EXPLORATION COMPANY



GEOPHYSICAL

SURVEYING

Spearpoint of the

Petroleum Industry

For ADVANCED
Seismic Equipment and
Technique

CALL **ADVECO** F-8007

622 FIRST NATIONAL BANK BUILDING
HOUSTON 2, TEXAS

C. W. BOCKOCK, III

GEO. D. MITCHELL, JR.

JAMES L. SAULS, JR.

PRACTICAL PETROLEUM ENGINEERS' HANDBOOK

Reprint of
SECOND EDITION

By JOSEPH ZABA
and
W. T. DOHERTY



This book was written by practical oil men. The tables were compiled so that they can be used by anyone to meet practical field situations without further calculations, and will fit 99% of the conditions under which the average operator is working in the field.

The second edition of the PRACTICAL PETROLEUM ENGINEERS' HANDBOOK has been completely revised and enlarged. Many changes which have been made in the Standard Specifications of the American Petroleum Institute, particularly in pipe specifications, are incorporated in this second edition. Several tables are rearranged and charts enlarged to facilitate their use. Table of Contents and Index are more complete. Also about 90 pages of new formulae, tables, charts and useful information have been added.

This handbook was compiled and published for the purpose of saving the time of operators, engineers, superintendents, foremen and others.

TABLE OF CONTENTS

Chapter I	—General Engineering Data
Chapter II	—Steam
Chapter III	—Power Transmission
Chapter IV	—Tubular Goods
Chapter V	—Drilling
Chapter VI	—Production
Chapter VII	—Transportation

Semi-Flexible Fabrikoid Binding, size 6 x 9, 492 Pages. Price: \$6.00 Postpaid

Send Checks to the
GULF PUBLISHING COMPANY
P. O. BOX 2608, HOUSTON, TEXAS

FIRST IN OIL FINANCING 1895-1946

THE FIRST NATIONAL BANK AND TRUST COMPANY OF TULSA

MEMBER FEDERAL DEPOSIT INSURANCE CORPORATION

THE GEOTECHNICAL CORPORATION

Roland F. Beers
President

1702 Tower Petroleum Building

Telephone L D 101

Dallas, Texas

Already the best...

MULTIPLE SHOT OIL WELL SURVEY INSTRUMENT

but we improved it!

Although the Eastman Multiple Shot has hung up such outstanding records as surveying **1,000,000 feet without a failure** progressive Eastman engineers have designed and built a finer, better and even more dependable post-war model and have thoroughly proved its performance in more than a year of actual field service.

Ask for a free demonstration of the new Eastman Multiple Shot in your office or before your engineering staff. See the many improvements—learn the advantages of having a complete Directional Survey made of your well bores from the top to the bottom in a single run of the instrument. No obligation — just call the nearest of our 22 offices.

Eastman

OIL WELL SURVEY COMPANY

GENERAL OFFICES: DENVER, COLORADO

DIVISION OFFICES: DENVER — LONG BEACH — DALLAS — HOUSTON

A WARTIME DREAM *Failing's "2500"* ... COME TRUE

EVERYONE KNOWS that the way to get the "low down" on drilling equipment is to hunt up a practical driller.

CHECK THE HIGH STANDARDS of all *Failing*-built equipment with any driller who has operated it. He'll tell you there is no finer or more dependable equipment anywhere.

DURING THE WAR DAYS, *Failing* ENGINEERS began designing in their minds the type of portable drilling equip-

ment that would meet the advanced needs of the industry when peace came. Out of these dreams has evolved the *Failing* 2500 Drill.

BE SURE TO INVESTIGATE this new drill before making any commitments for new equipment.

Check these Points

Light Weight Streamlined Design
New Type Balanced Crown Block
Easily Removable, All Steel Table
Air Actuated Double Drum Draw Works

Patented Floating Gear Box
Hydraulic Throttles
Mud Pump Unitized with Drill
Engines Compounded through Fluid Drive

Geo. E. Failing Supply Co.

MANUFACTURERS • PORTABLE DRILLING EQUIPMENT

HOUSTON, TEXAS

ENID, OKLAHOMA

MIDLAND, TEXAS

EXPORT OFFICE • 30 ROCKEFELLER PLAZA • NEW YORK 20, N.Y.



New Bulletin
GIVING COMPLETE DETAILS
AND SPECIFICATIONS

*Write for your
copy today*

Opportunity For a Geologist

The Geological Society of America will appoint an Assistant Secretary

Duties: To assist the Secretary and, under his direction, to supervise administrative and publication work of the Society. **Age:** Preferably not over 40 at time of appointment. **Qualifications:** Geological education and standing equivalent to that required for fellowship in the Society; ability and preferably some experience with the problems of publishing including editorial work and general business management; good judgment, tact, good address. Either a man or a woman will be considered. **Salary:** Opening salary \$4500 with annual increases and maximum salary at discretion of Council. The rate of advancement and maximum salary would be determined according to the success (as judged by the Council) with which the duties of the position are performed. **Retirement:** At age 65, at not over half salary, depending upon age at time of appointment.

Applications should be submitted simultaneously to each member of the undersigned special committee and should be accompanied by biographical sketches and at least two letters of recommendation from geologists acquainted with their qualifications. The closing date for applications is February 1, 1947. Interviews will be arranged for most promising candidates and the Committee will meet on or about April 1, 1947 to select a list of not less than three candidates for presentation to the Council for its consideration and the appointment of one on or about April 26, 1947.

H. R. ALDRICH, *Secretary*
The Geological Society of America
419 West 117 Street
New York 27, N.Y.

A. I. LEVORSEN, *Chairman*
Department of Geology
Stanford University, California

JAMES GILLULY, *Chairman*
Department of Geology
University of California
Los Angeles 24, California

TECTONIC MAP OF SOUTHERN CALIFORNIA

BY

R. D. REED and J. S. HOLLISTER

Map and four structure sections printed in ten colors on durable ledger paper, 27 x 31 inches. Scale, $\frac{1}{8}$ inch = 1 mile.

From "Structural Evolution of Southern California," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 20, No. 12 (December, 1936).

PRICE, \$0.50, POSTPAID IN TUBE

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

BOX 979, TULSA 1, OKLAHOMA, U.S.A.

R. W. LAUGHLIN

L. D. SIMMONS

WELL ELEVATIONS



Oklahoma, Texas, Kansas, New Mexico,
Louisiana, Arkansas, Illinois, Indiana,
Kentucky, Mississippi

GENERAL OFFICE:
OKLAHOMA BLDG.—TULSA, OKLAHOMA



Our big Operations Plant was used by the Government during the war for army map making.

TOBIN SERVICES INCLUDE

Photographic Maps
Regional Base Maps
Land Ownership Maps
Pipeline Mapping
Abstract Services
Micro-film Recording

We are again operating the Plant, which enables us to increase the scope of our services to the Oil Industry and other users of Tobin Maps.

EDGAR TOBIN AERIAL SURVEYS

OFFICES:

502 W. MISTLETOE, SAN ANTONIO, TEXAS



THE MAPPING AGENCY FOR THE OIL INDUSTRY



1947 Printing in Paper Covers. Handy to Take with You

POSSIBLE FUTURE OIL PROVINCES OF THE UNITED STATES AND CANADA

CONTENTS

Foreword

Alaska

Western Canada

Pacific Coast States

Rocky Mountain Region

Northern Mid-Continent States

West Texas

Eastern Canada

Eastern United States

Southeastern United States

By A. I. Levorsen

By Philip S. Smith

By Alberta Society of Petroleum Geologists

By Pacific Section, American Association of Petroleum Geologists

By Rocky Mountain Association of Petroleum Geologists

By Tulsa Geological Society

By West Texas Geological Society

By Geological Survey of Canada, Quebec Bureau

of Mines, and Newfoundland Geological Survey

By Appalachian Geological Society

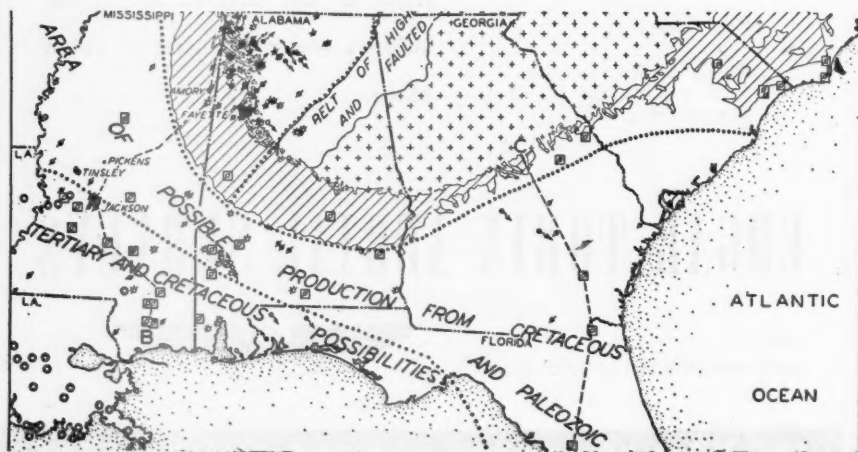
By Mississippi Geological Society

154 pp., 83 figs. Paper cover. 6 x 9 inches

Third printing. Reproduced by photo offset process from original printing of 1941

PRICE, \$1.50, POSTPAID (\$1.00 TO MEMBERS AND ASSOCIATES)

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
BOX 979, TULSA 1, OKLAHOMA, U.S.A.



ATLAS EXPLOSIVES

designed especially for

GEOPHYSICAL PROSPECTING

Atlas Petrogel No. 1 HV 60%. The outstanding explosive of the seismic prospecting field. A gelatinous type explosive made for the job. Combining high strength with high velocity and water resistance, it handles easily in the field—will force through mud in drill holes without bulging the cartridges—yet is easy to prime. Packed by weight.

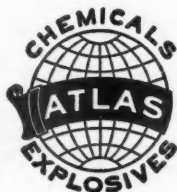
2½ lbs. x 2" diameter

5 lbs. x 2¼" diameter

Atlas Twistite Assembly. A fast coupling device enabling the blaster to connect Atlas Petrogel explosives into continuous rigid columns. Each cartridge of explosive is threaded into a sleeve, which in turn, may be threaded over an adjacent cartridge. Convenient to use.

Atlas Technical Service. Call on the nearest Atlas Office for service on special explosives problems. Our trained representatives will be glad to help.

Remember—You Get the Extra Safety of Manasite Too



ATLAS

Powder Company

Wilmington 99, Delaware



FIG. 20.—Cerro Bernal, volcanic plug. (Reproduction of sketch by Captain G. F. Lyon, 1828; redrawn by F. S. Howell.)

GEOLOGY OF THE TAMPICO REGION MEXICO

By JOHN M. MUIR
1936

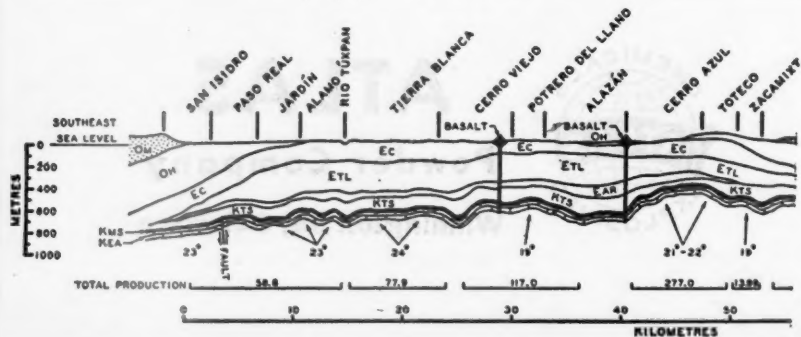
"This book deals primarily with the geology of the Tampico embayment, but the author has viewed his objective with a broad perspective and presents the oil fields of that area against a background of the geologic history of Mexico. . . . (It) is an authoritative work by an expert on an area which has been one of the most important oil-producing regions of the world. The excellent areal geologic map of the Tampico embayment and the structure maps of the oil fields are significant contributions to Mexican geology. The extensive faunal lists from definite localities in each formation will be welcomed by students of earth history who seek to correlate the events in Mexico with the panorama of geologic development throughout the world."—Lewis B. Kellum, of the University of Michigan, in *Bull. Amer. Assoc. Petrol. Geol.*

280 pp., including appendix, bibliography, gazetteer, index, 15 half-tones, 41 line drawings, including 5 maps in pocket, 212 references in bibliography
Bound in blue cloth; gold stamped; paper jacket. 6 x 9 inches.

PRICE, \$4.50, POSTPAID (\$3.50 TO MEMBERS AND ASSOCIATES)

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

BOX 979, TULSA 1, OKLAHOMA, U.S.A.



PRICE LIST OF THE BULLETIN THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

Box 979, Tulsa 1, Oklahoma, U.S.A.

The monthly *Bulletin* contains authoritative major articles on petroleum geology and allied subjects, and minor notes, discussions, and reviews. Annual subscription, \$15.00 (outside United States, \$15.40). Contents of Vols. I-XX (1917-1936) are indexed in detail in the *Comprehensive Index* of all A.A.P.G. publications (1917-1936); these volumes and the Index may be consulted at Association headquarters and in many college and public libraries. Volumes and numbers remaining for sale are listed here. Educational institutions are invited to write for special prices on part or complete sets insofar as available.

BULLETINS AVAILABLE (1921-1934). See COMPREHENSIVE INDEX FOR CONTENTS ALSO, ANNUAL CONTENTS INDEXED IN EACH DECEMBER NUMBER

			Members	Non-Members
1921	VOL. V. NOS. 3-6.....	(4 Nos., total price to all, \$2.00).....	Each (\$1.00)	\$1.50
1922	VOL. VI. NOS. 3-6.....	(4 Nos., total price to all, \$2.00).....	Each (\$1.00)	1.50
1923	VOL. VII. NOS. 1-4.....	(4 Nos., total price to all, \$3.00).....	Each (\$1.00)	1.50
1924	VOL. VIII. NOS. 1-4.....	(4 Nos., total price to all, \$3.00).....	Each (\$1.00)	1.50
1926	VOL. X. NOS. 5-7, 9.....	(4 Nos., total price to all, \$3.00).....	Each (\$1.00)	1.50
1927	VOL. XI. NOS. 6.....	.....	Each (\$1.00)	1.50
1928	VOL. XII. NOS. 7-11.....	.....	Each (\$1.00)	1.50
	Full Vol., 12 mos., cloth.....	.....	Each (\$5.00)	6.00
1929	VOL. XIII. NOS. 1-12.....	.....	Each (\$1.00)	1.50
	Full Vol., 12 mos., cloth, or paper covers.....	.....	Each (\$5.00)	6.00
1930	VOL. XIV. NOS. 1-12.....	.....	Each (\$1.00)	1.50
	Full Vol., 12 mos., cloth, or paper covers.....	.....	Each (\$5.00)	6.00
1931	VOL. XV. NOS. 1-12.....	.....	Each (\$1.00)	1.50
	Full Vol., 12 mos., cloth, or paper covers.....	.....	Each (\$5.00)	6.00
1932	VOL. XVI. NOS. 1-5.....	.....	Each (\$1.00)	1.50
1933	VOL. XVII. NOS. 1-3.....	.....	Each (\$1.00)	1.50
1934	VOL. XVIII. NOS. 9-12.....	.....	Each (\$1.00)	1.50

BULLETINS AVAILABLE (1937-1946) SINCE PUBLICATION OF COMPREHENSIVE INDEX ANNUAL CONTENTS INDEXED IN EACH DECEMBER NUMBER

Following prices in parentheses apply to all members.

1937	VOL. XXI.—Each number.....	(\$1.00)	1.50
	NO. 11—134 pp. ARK.: Pennsylvanian. GEN.: Evaluation of petroleum index of refraction; colorimetric determination of oil open-space replacements. KAN. and OKLA.: Source beds. RUSSIA: Urals. TEX.: Laredo.		
	NO. 12—129 pp. ARABIA: "Black Sea" conditions in Arabian Sea. KAN.: Permian. N. Y.: Oriskany. OKLA.: Permian. PA.: Oriskany. TEX.: Sand Hills, Crane Co.		
1938	VOL. XXII.—Each number.....	(\$1.00)	1.50
	NO. 4—124 pp. GEN.: Appalachian field history; bibliography of structure maps and sections of oil states; folds in three dimensions. MICH.: Oil and gas.		
	NO. 5—116 pp. GEN.: Future of geologist; Oriskany sandstone petrology; geological limitations to oil law. N. MEX.: New section of Trinity age.		
1939	VOL. XXIII.—1,922 pp. 12 Nos. Each number.....	(\$1.00)	1.50
	NO. 1—120 pp. CALIF.: Reef Ridge shale; Santa Maria Valley field. NEB.: Agate anticline. UTAH: "Park City" beds, Uinta Mts.		
	NO. 2—160 pp. LA.: Vicksburg fauna. OKLA.: Keokuk pool. TEX.: Harris Co.; heaving shale. UTAH: Washington Co.		
	NO. 3—180 pp. LA.: Lisbon. OKLA.: Osage. TEX.: McFadden Beach.		
	NO. 4—164 pp. CALIF.: Ridge Basin. LA.: Barataria Bay. MO.: Bainbridge formation. MONT.: Baker-Glendive anticline. OKLA.: Verden shoestring. TEX.: Orange field; salt erosion, Gulf. U.S.S.R.: Salt domes. WYO.: Wind River Canyon.		
	NO. 5—140 pp. GENERAL: Two tilts. KAN.: Greenwich pool. OKLA.: Dora pool. PERU: Agua Caliente anticline. TEX.: Travis Peak formation; Fairbanks and Satsuma fields. TURKEY: Southern.		
	NO. 6—218 pp. REVIEW OF DEVELOPMENTS.		
	NO. 7—180 pp. GEN.: Rock units. KAN.: Hugoton gas. OKLA.: Arbuckle asphalt. TEX.: Panhandle gas; Carlos structure and Ferguson Crossing, Grimes and Brazos Cos.		
	NO. 8—124 pp. ARK.: Basilosaurus. CALIF.: Potrero Hills gas. GEN.: Rocky Mtns.; black shale. KAN.: Loess. LA.: Stream patterns. S. DAK.: Pennington Co. TEX.: Ben Bolt and Magnolia City fields, Jim Wells Co.; Muralla field, Duval Co. TRINIDAD.		
	NO. 9—148 pp. GEN.: Isostatic layer; electrical logging; Gulf datum planes. ILL., IND., KY.: Coals; Salem field, Marion Co. MISS.: Jackson Eocene, TEX.: Proration.		

NO. 10—164 pp. ALA.: Citronelle. CALIF.: Wasco field, Kern Co. GEN.: Oligocene-Miocene. ILL.: Basin fields; Pennsylvanian; Cambrian inlier. N. MEX.: Salado formation. TEX.: Goldsmith field, Ector Co.; Salado. WYO.: Wind River Canyon.

NO. 11—148 pp. FLA.: Everglades deep test. GEN.: Permian; marine and non-marine sediments. NEB.: Permian. N. MEX.: Castile salt, potash, anhydrite. TEX.: Gulf Coast; Amelia field, Jefferson Co.; Permian.

NO. 12—172 pp. GEN.: Drilling time; Cincinnati arch. KAN.: Permian. KY.: St. Peter; McClosky productive areas. LA.: Starks field, Calcasieu Parish.

1940 VOL. XXIV.—2,232 pp. 12 Nos. Paper. Each number.....(\$1.00) 1.50

NO. 3—208 pp. GEN.: Gulf Coast Miocene; barium in Appalachian brines. LA.: Miocene; interior salt domes. OHIO: Secondary recovery. OKLA.: Morrow group, Adair Co. TEX.: Apco structure, Pecos Co.; Sejita structure, Duval Co.

NO. 4—148 pp. ARK.: Dorcheat pool, Columbia Co. AUSTRALIA: Permian. CALIF.: Whittier Quadrangle; Kettleman Hills; Paloma field, Kern Co. COLO.: Permian. LA.: Sparta-Wilcox. MINN.: Pre-Cambrian, Cambrian. OHIO: Paleozoic, pre-Cambrian, Delaware Co. OKLA.: Osage, Washington, Nowata Cos.; deepest well, Washita Co. TEX.: Lissie and Beaumont, Gulf Coast; Sparta-Wilcox; shoreline, Brazoria Co.

NO. 5—188 pp. GEN.: Mississippian, Eastern Interior; geochemical exploration.

NO. 6—204 pp. RECENT DEVELOPMENTS.

NO. 7—196 pp. CALIF.: Rio Bravo field, Strand field, Kern Co. TEX.: Cretaceous ammonoids. WYO.: Oil-field waters.

NO. 8—176 pp. GEN.: Exploration methods; young graduates and field experience; source of hydrogen; underground gas storage. IA.: Wildcat well, Union Co. TEX.: Henderson pool, Clay Co.; K.M.A. field, Wichita Co.

NO. 9—176 pp. CANADA: Turner Valley Paleozoic limestone. CALIF.: Bakersfield Eocene coal. COLOMBIA: Jurassic-Cretaceous. GEN.: Radioactivity of rocks; GULF: Cook Mtns. N. MEX.: Caballos novaculite. TENN.: Lower Ordovician (St. Peter). VENEZUELA: Jurassic-Cretaceous. W. INDIES: Paleogene of Barbados.

NO. 10—160 pp. CALIF.: History; Eocene Yokut sandstone. GEN.: Paleontology. KAN.: Hugoton field porosity, permeability. TEX.: Saxet field, Nueces Co.; Rogers pool and Bonita discovery, Montague Co.; Aspermont pool, Stonewall Co.

NO. 11—204 pp. CALIF.: San Joaquin Valley Eocene. GEN.: Carbohydrates of oil and coal; unconformities and accumulation. LA.: Wilcox Eocene; Neale, Beauregard Parish. MICH.: Buckeye, Gladwin Co. MISS.: Surface. OKLA.: Ramsey, Payne Co.; Billings, Noble Co. TEX.: Wilcox Eocene; Pittsburg, Camp Co. W. VA.: Devonian.

NO. 12—164 pp. CALIF.: Miocene fishes, Torrance field. GEN.: Water cones; Permian crude. LA.: Gulf heavy minerals. MICH.: Isopach, Ellsworth-Traverse limestones. OKLA.: Structural interpretation, gravity anomalies. TEX.: Gulf heavy minerals; Hoffman field, Duval Co.; Jones Co. TRINIDAD: Los Bajos fault.

1941 VOL. XXV.—Each number.....(\$1.00) 1.50

NO. 12—167 pp. GEN.: Shadowgraphic maps; free-oil deposition; traceslip faults; stratigraphy; radioactivity logging. N. MEX.: Sacramento Mtns. Mississippian.

1942 VOL. XXVI.—1,893 pp. 12 Nos. Paper. Each number.....(\$1.00) 1.50

NO. 1—152 pp. APPAL.: Geochemistry, gas. GEN.: Silurian, Mississippi Basin; unconformities; spacing. KAN.: McLouth field, Jefferson and Leavenworth Cos. N. MEX.: Salado formation, potash; Seven Rivers formation, Eddy Co. S. DAK.: Viola graptolites, Black Hills. VENEZUELA: Ortiz and Guarumen sandstones.

NO. 2—152 pp. CALIF.: Stratigraphy; Cretaceous; Del Valle field, Los Angeles Co. GEN.: Free oil accumulation. TEX.: Sewell-Eddleman area, Young Co.; Permian paleogeography; Eocene, Zapata Co.; Washburn field, La Salle Co.; McKee and Waddell sands, Simpson Ordovician, West Texas. UTAH: Laccolithic mountains, traps.

NO. 3—228 pp. CALIF.: Earthquake, Dominquez field, Los Angeles Co. GEN.: Member list; auditor's report. KAN.: Patterson pool, Kearny Co. MONT.: Madison Mississippian. N. DAK.: Stratigraphy. RUSSIA: Artinskian Permian. TEX.: Pre-Cretaceous, Edwards Plateau; Barnhart field, Reagan Co.

NO. 5—204 pp. CALIF.: Sutter Buttes. COLOMBIA: Honda district. GEN.: Pseudoabyssal sediments; salty ground waters, Atlantic and Gulf coasts; oil-field waters; annual reports. MONT.: Cedar Creek anticline. TEX.: Silurian graptolite, Crane Co.

NO. 6—216 pp. RECENT DEVELOPMENTS

NO. 7—132 pp. ARK.: Developments; Midway field, Lafayette Co. GEN.: Annual addresses; exploration; geology, war, peace; teaching; drilling-time logs; appraisals, oil reservoirs. GULF: Tertiary microfossils. LA.: Developments.

NO. 8—124 pp. COLO.: Gore area. GEN.: Discovery methods. MONT.: Oil-field water. N. DAK.: Stratigraphy. TEX.: Ellenburger; Pennsylvanian anhydrite.

NO. 9—136 pp. ARK.: Schuler field, Union County. NEB.: Cretaceous. TEX.: Well spacing, Columbia field, Brazoria Co.

- NO. 10—140 pp. CALIF.: Crocker Flat, Temblor Range. COSTA RICA: Amoura shale. GEN.: Lantern-slide copy. ILL.-IA.: Pennsylvanian. ILL.-IND.: Chester sandstone; New Harmony field. LA.: Morehouse Paleozoic. N., S. DAK.: Regional. TEX.: Payton pool, Pecos and Ward Cos.
- NO. 11—98 pp. GEN.: Stratigraphical analysis and environmental reconstruction. TEX.: Graptolites, Crane Co.
- NO. 12—98 pp. GEN.: Engineering geology; calculating thickness; annual index.
- 1943 VOL. XXVII—1,674 pp. 12 Nos. Paper. Each number.....(\$1.00) 1.50
- NO. 4—154 pp. MEX.: Upper Jurassic. ROCKY MTNS.: Structure. TEX.: Wasson field, Yoakum and Gaines Cos.; Embar field, Andrews Co. VA.: Natural coal gas.
- NO. 5—134 pp. CALIF.: Tertiary. GEN.: Annual reports. GULF: Tuscaloosa formation. KAN.-OKLA.: Desmoinesian, Missourian. MICH.: Thunder Bay Traverse rocks. S. DAK.: Rapid City water wells. TEX.: Seguin formation; Dockum conglomerates.
- NO. 6—172 pp. RECENT DEVELOPMENTS.
- NO. 7—152 pp. GEN.: Annual addresses; discovery thinking; geology, paleontology, geophysics, reserves, discoveries, economics, war; developments, SE. U.S.; cabletool logs.
- NO. 8—136 pp. LA.: Anse La Butte, St. Martin Ph.; Jennings field, Acadia Ph. TENN.: Structure. TEX.: L. Cret. foraminifera and ostracoda; ground water at Houston.
- NO. 9—112 pp. GEN.: Marine micro-organisms and petroleum; faults. TEX.: Pre-Trinity. W. VA.: Metamorphism of coal.
- NO. 10—120 pp. CALIF.: Santa Maria district; Eocene, Chico Martinez area. GREAT PLAINS: Big Snowy group. OKLA.: Simpson graptolites. ROCKY MTNS.: Crude oils.
- NO. 11—160 pp. GEN.: Aerial photographs. GULF: Jurassic. VA.: Deep well, Russell Co. W. VA.: Deep well, Harrison Co.
- NO. 12—112 pp. CALIF.: Radiolarites, Santa Maria basin. GEN.: Chemical analysis of crudes. N. DAK.: Tertiary; Williston basin. OKLA.: Spavinaw granite. VENEZUELA: Fossils in metamorphics.
- 1944 VOL. XXVIII—1,812 pp. 12 Nos. Each number.....(\$1.00) 1.50
- NO. 3—148 pp. ARK.: Developments, 1942. GEN.: Membership; audit. LA.: Developments, 1942. MEX.: Northern geology.
- NO. 4—128 pp. CALIF.: Cretaceous and Paleocene, Santa Lucia Range. KY.: "Corniferous," Estill Co. LA.: Grabens; developments, 1942. TEX.: Pecan Gap, Wolfe City, and Annona formations; highest structural point; grabens.
- NO. 5—124 pp. GEN.: Annual reports; velocity corrections; reserve estimates. GULF: Cotton Valley beds.
- NO. 6—196 pp. RECENT DEVELOPMENTS. COLOMBIA: Free oil in ammonites. OKLA.: Viola graptolites.
- NO. 7—180 pp. CALIF.: Tumey sandstone, Fresno Co.; exploratory wells. GEN.: Annual addresses; radioactivity and petroleum genesis; paleoecology, Middle Permian. MIDDLE EAST: Oil mission. MISS.: Field and salt-dome names. OHIO: Petroliferous iron ore. OKLA.: Broken Arrow coal, Rogers, Wagoner, and Tulsa Cos. TEX.: Miocene; elasticity of reservoir, E. Tex.; dolomite porosity in Devonian, W. Tex.
- NO. 8—172 pp. COLOMBIA: Thrust fault. GEN.: Data on oil reserves. MEX.: Cretaceous. WYO.: Como Bluff anticline, Albany and Carbon Cos.
- NO. 9—168 pp. GEN.: Stratigraphic thickness in parallel folds. GULF: Oligocene; Anahuac formation. LA.: Structure of deep domes. MO.: Bourbon High, Crawford Co.
- NO. 10—144 pp. ARGENTINA: Tupungato field, Mendoza. CHINA: General geology; Red Basin, Szechuan province. E. INDIES: Sedimentary basins. GEN.: Petroleum distribution; origin and accumulation; elevations with plane table and speedometer. ILL.: Devonian subsurface; Sandoval pool, Marion Co. TEX.: Concord salt dome, Andrews Co.; fossils in Buda limestone, Denton Co.; Fullerton pool, Andrews Co.
- NO. 11—112 pp. APPAL.: Underground gas storage. ARK.: Moorefield formation and Ruddell shale, Batesville district. COLOMBIA: Thrust fault. NEW MEX.: Upper Permian Ochoa series, Delaware basin. TEX.: Upper Permian Ochoa; salt diffusion in Woodbine sand; ammonoids in upper Cherry Canyon, Delaware group; South Tyler, and Sand Flat fields, Smith Co. VENEZUELA: Fusulinids, La Quinta formation.
- NO. 12—140 pp. FLA.-GA.: Stratigraphy, structure. GEN.: Index; reservoir data.
- 1945 VOL. XXIX—1,824 pp. 12 Nos. Each number.....(\$1.00) 1.50
- NO. 2—128 pp. GEN.: Mississippian and Pennsylvanian of N. Amer.; size distribution of sand. LA.: Ruston gas field, Lincoln Parish. OKLA.: Thrust faulting, Arbuckle Mtns. TEX.: Cretaceous, Tyler basin; South Houston salt dome and oil field, Harris Co.; crystalline rocks in deep well, Winkler Co.; deep test, Moore Co.
- NO. 3—160 pp. GEN.: Maddox spoon; origin of petroleum; members; financial. TEX.: Rise of water level to defective gas well, Harris Co.; Deep test, Culberson Co.
- NO. 4—64 pp. ARK.: Calhoun field, Columbia Co. GEN.: Paleogeographic and palinspastic maps. MONT.: Jurassic Ellis formation. OKLA.: Graptolites, Carter Co. TEX.: Lower Ordovician and Upper Cambrian.

NO. 5—152 pp. GEN.: Annual reports; Wallace Pratt, Powers medalist; college geology students. KAN.: Ness Co. MICH.: Silurian brine, Bay City. S. AMER.: Oil possibilities. NO. 6—228 pp. RECENT DEVELOPMENTS. TEX.: New Hope field, Franklin Co.; Bacon limestone, E. Tex.

NO. 7—208 pp. ATLANTIC COASTAL PLAIN: Subsurface. CALIF.: Upper Cretaceous in Great Valley. GEN.: Presidential addresses; middle Jurassic in Western Interior; geological calendar. MISS.: Upper Cretaceous fossils from wells. OKLA.: Graptolites, Carter Co. TEX.: Igneous rocks from deep wells. W. Tex.

NO. 8—168 pp. ALBERTA: Reservoir, Turner Valley. COLOMBIA: Petroleum geology. GEN.: Time of oil accumulation; textural standard for sample logs; research in exploration. LA.: Ground-water geology, Camp Polk. MD.: Deep test, Wicomico Co. UTAH: Mississippian and Pennsylvanian, Dry Lake, Logan Quadrangle.

NO. 9—144 pp. GEN.: Recent sedimentation and search for petroleum; vertical source in oil and gas accumulation. GULF COAST: Sedimentation. MONT.: Marine Jurassic, Sweetgrass arch. TEX.: Pre-Permian axes of deposition, W. Tex.

NO. 10—160 pp. GEN.: Radioactivity, organic content, sedimentation; photography of megafossils; research program. ORE.: Geology and oil and gas. TEX.: Subsurface Lower Cretaceous, S. Tex. WASH.: Geology and oil and gas.

NO. 11—156 pp. ALBERTA: Cretaceous of Vermilion area. COLO.: Las Animas arch, Lincoln, Cheyenne, Kiowa Cos. GEN.: Petroleum reservoirs; exploratory drilling, 1938—1944; strength of the earth. ILL.: Rosiclare-Fredonia contact, Hardin and Pope Cos. ROCKY MTS.: Developments, 1944.

NO. 12—132 pp. GEN.: Classification of oil and gas accumulations; use of aerial photographs; Permian Word formation; surface and seismic exploration party. TEX.: Coastal Plain Quaternary and Oakville, Cuero, and Goliad formations; Balcones, Luling, and Mexia fault zones; Pickton field, Hopkins Co.; Merigale field, Wood Co.

1946 VOL. XXX.—2120 pp. Each number (\$1.00) 1.50
WHOLE VOLUME: Bound in two parts. Cloth (\$4.00) 17.00

NO. 1—156 pp. CALIF.: Los Banos district, San Joaquin Valley. E. INDIES: Oil basins; reef corals. GEN.: Hydrocarbons from fatty acids; submarine slumping; Paleozoic conodonts; classification of oil possibilities; naming multiple sands. TEX.: Waller and Harris Cos.; Devonian "pay," TXL pool, Ector Co.

NO. 2—148 pp. ALA.: Pre-Selma Up. Cretaceous. ALBERTA: Jurassic-Cretaceous. GEN.: Origin of continental shelves. MONT.: Jurassic-Cretaceous boundary. ORE.: Up. Nehalem River basin, PERU: SE. reconnaissance. TEX.: Katy field, Waller Co.; Low. Pennsylvanian terminology.

NO. 3—172 pp. ECUADOR: Up. Cretaceous and Paleocene micropaleontology. EUROPE: Carpathian oil fields. GEN.: Porosity through dolomitization; members; financial. NEBR.: Boice shale, Mississippian. WEST VA.: Drill cuttings.

NO. 4—168 pp. ARGENTINA: San Pedro oil field, Salta. ARK.: Penters chert, Batesville. CALIF.: Miocene conglomerates, Puente and San Jose Hills. COLO.: Gramp's field, Archuleta Co. GEN.: Redox potential of marine sediments; asphaltic sands. MEX.: Caborca, Sonora. S. AM.: Tectonic framework. SINAI: Triassic conodonts.

NO. 5—168 pp. ALA.: Vick formation, pre-Tuscaloosa. GEN.: Organic material into petroleum; "Jacob staff"; aerial photography; annual reports and minutes; college geology students. KAN.: buried pre-Cambrian hills, Barton Co.

NO. 6—264 pp. RECENT DEVELOPMENTS. PERU: Southeastern reconnaissance. TURKEY: Harbolite, carbonaceous hydrocarbon.

NO. 7—144 pp. GEN.: Presidential addresses; science legislation; geologists in military service; production engineering; grain roundness; mss. preparation. TEX.: Gas reserves; Quaternary. VA.-TENN.: Ordovician.

NO. 8—212 pp. GEN.: Geological directory. KAN.: Siluro-Devonian. MON.: Ellis, Amsden, Big Snowy group, Judith basin. UTAH: Paleozoic-Mesozoic, Uinta Mtns.

NO. 9—188 pp. ALASKA: Possibilities. FRANCE: Aquitaine basin. GEN.: Quimbys Mill member, Platteville formation, Ordovician; oölite and oöolith. GERMANY: Oil fields. S. AMER.: NW. framework. UNITED KINGDOM: Occurrence of oil.

NO. 10—176 pp. COLO.: Paleozoic, Las Animas arch, Baca, Las Animas, and Otero Cos. GEN.: Preparation of lantern slides. KAN.: Kinderhook dolomite, Sedgwick Co. N.MEX.-TEX.: Algae reefs, Ogallala formation, Llano Estacado Plateau. TEX.: Alunite at Woodbine-Eagle Ford contact. VENEZ.: Maracaibo basin.

NO. 11—184 pp. ARIZ.: Faulting, Grand Canyon. GEN.: Fault structures; spectrochemical logging of limestones; well data and faulting; grain size in carbonate rocks; quotation mark in science; Jacob Staff measurements; organic material into petroleum; research schedule. N.MEX.-W. TEX.: Permian. N. CAR.: Atlantic Coastal Plain floor and continental slope. OKLA.: West Edmond field. TEX.: Hawkins field, Wood Co.

NO. 12—140 pp. GEN.: Oceans and continents; geological-geophysical exploration trends; exploratory drilling statistics; tectonics. OKLA.: Elmore embayment, Garvin Co. S. AMER.: Tectonic framework.



**WE DEPEND ON THE
REED FOR ALL OUR
CORING JOBS!**

REED 'BR' *Wire Line* CORE DRILL

Operators in every part of the world "Core with Confidence" with the Reed "BR" Wire Line Coring-Drilling Bit on bottom. They have learned through practice and experience that for positive results in hard or soft formations they can depend on Reed Core Drills.

COMPLETE CORING SERVICE
The REED KOR-KING CONVENTIONAL
The REED "BR" WIRE LINE
The REED STREAMLINED KOR-KING
FOR SMALL HOLE DRILLING



**HARD AND SOFT FORMATION
HEADS INTERCHANGEABLE**



REED ROLLER BIT COMPANY

POST OFFICE BOX 2119

HOUSTON, TEXAS

Hughes CORE BITS
BRING THE
BOTTOM-OF-THE-HOLE
TO THE
DERRICK FLOOR

STANDARD OF THE INDUSTRY

HUGHES TOOL COMPANY
HOUSTON, TEXAS

